Errata to

Poultry Waste Generation and Land Application in the Illinois River Watershed and Phosphorus Loads to the Illinois River Watershed Streams and Rivers and Lake Tenkiller

Expert Report of Dr. B. Engel

For
State of Oklahoma
In Case No. 05-CU-329-GKF-SAJ

State of Oklahoma v. Tyson Foods, et al.
(In the United States District Court for the Northern District of Oklahoma)

Dr. B. Engel, P.E.
Professor of Agricultural and Biological Engineering

September 4, 2008

Bernard Engel, Ph.D., P.E.

In an effort to meet the Court's deadline for submission of my report, inadvertent mistakes were made that were not discovered until early August. In early May prior to completion of my report, an affidavit was submitted requesting additional time to complete the report. The affidavit explained the time demands as the report was being developed**. "**The spring is a very busy time of the academic year. In addition to the normal university expectations, I have had a significantly increased workload in (a) annual personnel evaluation (more than 50 faculty and staff requiring approximately 4 hours each), (b) departmental budget preparation, (c) completion of significant committee activities for the academic year (serve as co-chair for a portion of University accreditation report; serve as chair for School of Industrial Engineering head search), and (d) increased activities at the end of the semester (student exit interviews, student organization banquets, two graduation ceremonies, student receptions). These academic demands have taken me away from my work on the expert report. Indeed, due to my academic responsibilities this spring, my work on the expert report has been unavoidably delayed."

In addition, Dr. Ji-Hong Jeon, who was assisting with the GLEAMS modeling components of the effort, was also under severe time constraints. He had recently taken a faculty position at Andong National University in South Korea and had significant time commitments in starting his program as well as dealing with increased efforts at the end of the semester.

Dr. Engel relied upon daily summaries of the GLEAMS model outputs produced by Dr. Jeon for these locations for the scenarios documented in Dr. Engel's report. The GLEAMS outputs were used (as described in Engel's report) as inputs by Dr. Engel to route phosphorus loads to gauging locations on the Illinois River at Tahlequah, the Baron Fork near Eldon and Caney Creek.

In early August, when responding to an inquiry from the defendants regarding some of the modeling work, a mistake in code that was used in running GLEAMS and summarizing phosphorus loads from GLEAMS for each of the three river locations considered (Tahlequah, Baron Fork near Eldon, and Caney Creek) was discovered.

A mistake in the fortran code used to run GLEAMS for each hydrologic response unit (HRU – a unique combination of land use, soil properties, management and weather) within the watersheds above the three river locations considered (Tahlequah, Baron Fork near Eldon, and Caney Creek) was made. In addition to running the GLEAMS model, this code summarized the resulting GLEAMS outputs to create modeled P loads for the watersheds above each of the three river locations. The number of HRUs differs by watershed. The watershed above the Illinois River at Tahlequah was represented with 21 HRUs, while the watershed above Baron Fork near Eldon had 20 HRUs and the watershed for Caney Creek had 9 HRUs. Dr. Jeon created fortran code to run GLEAMS for each HRU and to summarize the results for each watershed. This code was setup for Baron Fork and copied to directories in which GLEAMS files for the Illinois River at Tahlequah and Baron Fork were kept. The code had the number of HRUs coded into it, and this was not updated when the code was copied into directories containing the Illinois River and Baron Fork GLEAMS files. This code was used in modeling the Illinois River and Baron Fork watersheds. As a result, the model outputs were incorrect since it was not updated to reflect the number of HRUs in these watersheds but rather reflected only 9 HRUs. Dr. Engel relied upon

the summarized GLEAMS results produced by the code with the incorrect number of HRUs in preparing his report.

Dr. Jeon discovered the mistake in HRUs in the code in April when gathering the materials considered for delivery to the defendants. The mistake was fixed at that time, and the GLEAMS model results were updated and these updated results were provided to the defendants with Dr. Engel's considered materials. However, due to the numerous end of academic year responsibilities of Dr. Jeon and Dr. Engel and the distance between them (Dr. Jeon had relocated to South Korea by this time), the updates were not communicated to Dr. Engel. Thus, Dr. Engel's report relied upon GLEAMS outputs that used incorrect model code, while the materials considered that were provided by Dr. Engel reflected the change in the fortran code and also contained updated GLEAMS outputs.

The correct GLEAMS outputs (as produced to the defendants in Dr. Engel's considered materials) have been used to update figures and tables in this Errata report that relied upon the incorrect GLEAMS outputs. These figures and tables were in section 10 and Appendix D of Dr. Engel's report. Text that referred to specific values mentioned in the figures and tables has been updated.

The substance of the major opinions in the Dr. Engel's expert report is unchanged.

1. Executive Summary/Conclusions

Hydrologic/Water Quality Modeling of Illinois River Watershed

2. For continued poultry waste application in the IRW at current levels, modeled P loads to Lake Tenkiller would increase during the first 30 years. For the next 70 years, P loads to Lake Tenkiller would stabilize at levels slightly above current Lake Tenkiller P loads due to P saturation of soils.
3. Cessation of poultry waste application in the IRW would decrease P loads to Lake Tenkiller. The reductions in P loads to Lake Tenkiller due to poultry waste land application cessation are limited to 18% during the first 10 years following cessation due to continued P load contributions from historical poultry waste application in the IRW that have elevated soil P. Following poultry waste land application cessation in the IRW, reductions in P loads to Lake Tenkiller would reach slightly over 50% by years 31-40.
4. For continued growth in the IRW poultry industry at a rate the same as that between 1982 and 2002, P loads to Lake Tenkiller would increase substantially. Within 40-50 years, P loads to Lake Tenkiller would increase substantially (increase of 70%).
7. P loads to Lake Tenkiller since 1954 have increased at approximately 8,000 lbs per year. Poultry waste application in the IRW is responsible for approximately 4,700 lbs of this increase each year.

Additional data from the IRW continue to become available. These data will be used to refine analyses reported herein and in new analyses as appropriate. Therefore, I reserve the right to update this report.

10. Hydrologic/Water Quality (GLEAMS) Modeling of Illinois River Watershed

Table 10.1. Modeled P Load at Gauging Stations in Illinois River Watershed

	Modeled P Load (lb)				
Year	Tahlequah	Baron Fork	Caney Creek	Total	Observed Total P Load (lb)
1997	217,778	74,623	14,782	307,183	241,107
1998	402,170	129,215	31,634	563,018	388,737
1999	465,292	75,421	10,791	551,504	497,928
2000	771,779	323,499	33,964	1,129,243	1,206,592
2001	490,232	77,069	24,819	592,120	650,074
2002	309,534	51,427	12,582	373,543	513,168
2003	136,278	7,940	4,299	148,516	128,993
2004	745,778	276,995	51,180	1,073,953	1,135,016
2005	399,936	80,522	11,191	491,649	367,106
2006	163,275	61,067	12,618	236,960	173,096

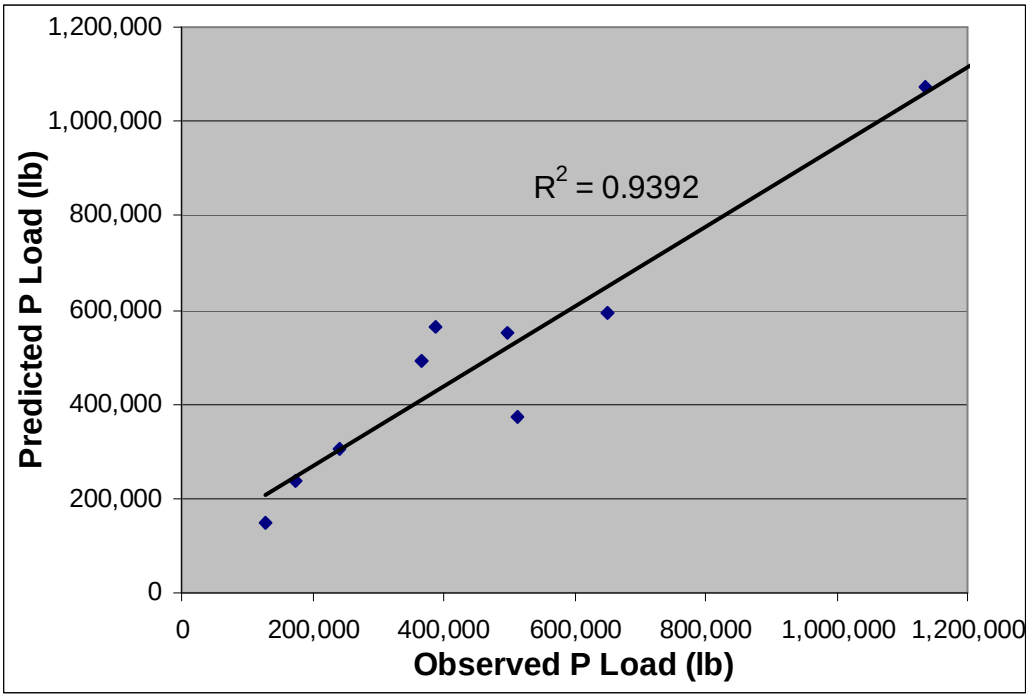

Figure 10.1. Relationship between Observed P Load and Predicted P Load to Lake Tenkiller for 1997-2006

10.2 Modeled P for Next 100 Years with (1) Continued Poultry Waste Application and (2) Poultry Waste Cessation in the IRW

For continued poultry waste application in the IRW, modeled P loads to Lake Tenkiller would increase during the first 30 years. For the next 70 years, P loads to Lake Tenkiller would stabilize at levels slightly above current Lake Tenkiller P loads due to P saturation of soils. Cessation of poultry waste application in the IRW would decrease P loads to Lake Tenkiller. The reductions in P loads to Lake Tenkiller due to poultry waste land application cessation are limited to 18% during the first 10 years following cessation due to continued P load contributions from historical poultry waste application in the IRW that have elevated soil P. Following poultry waste land application cessation in the IRW, reductions in P loads to Lake Tenkiller would reach slightly over 50% by years 31-40.

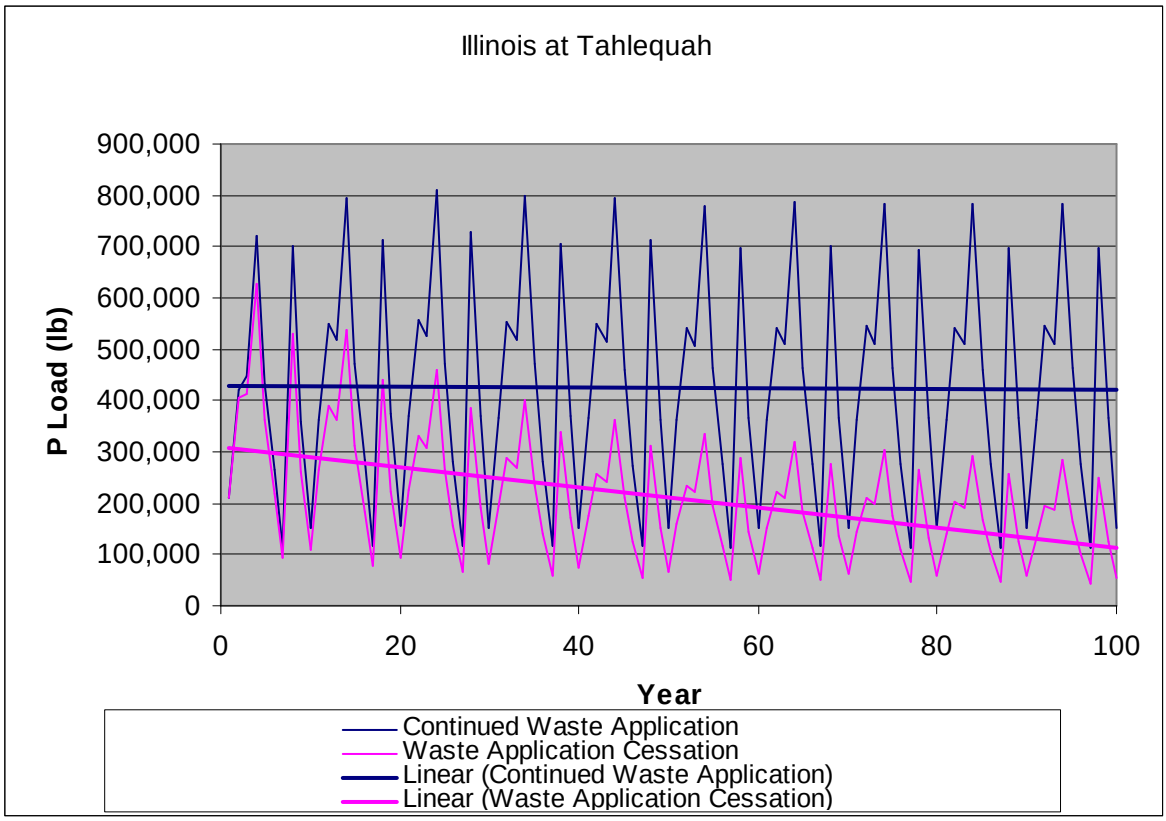

Figure 10.2. Modeled P Load at Tahlequah for Continuing Poultry Waste Application and for Cessation of Poultry Waste Application in the IRW

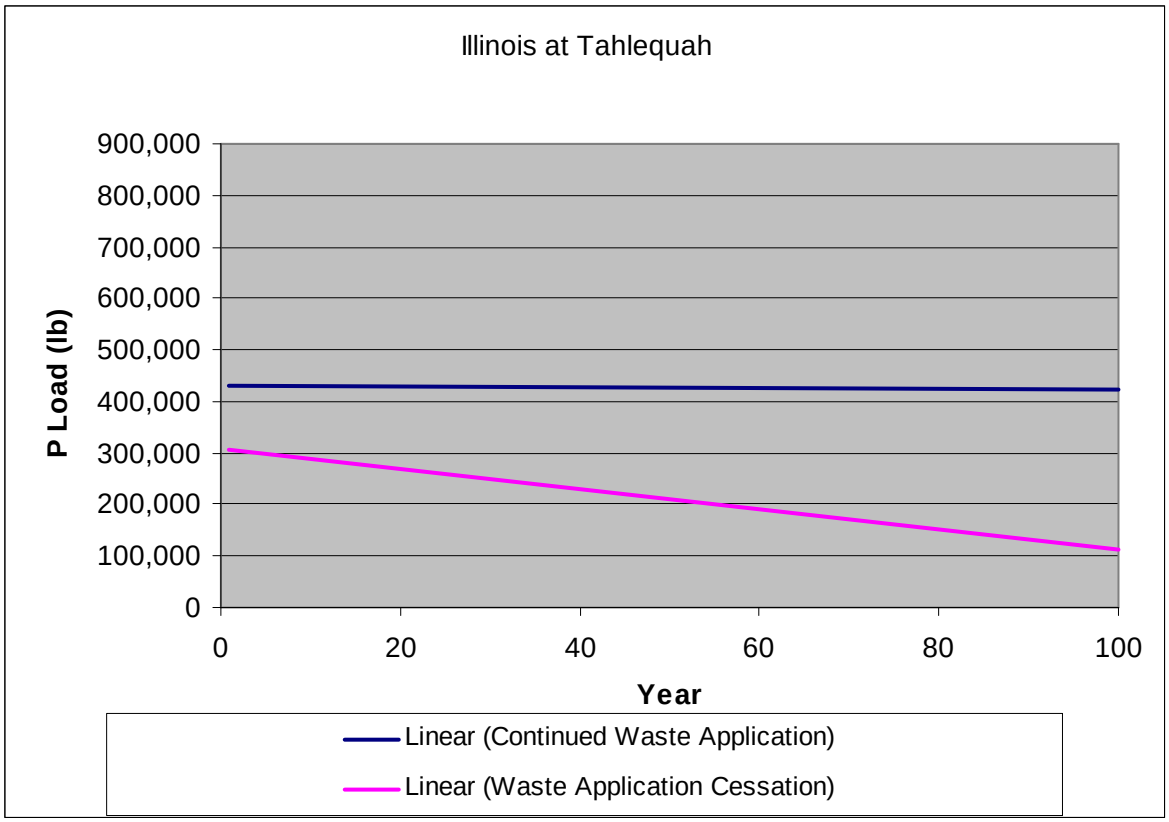

Figure 10.3. Trend Lines for Modeled P Load at Tahlequah for Continuing Poultry Waste Application and for Cessation of Poultry Waste Application in the IRW

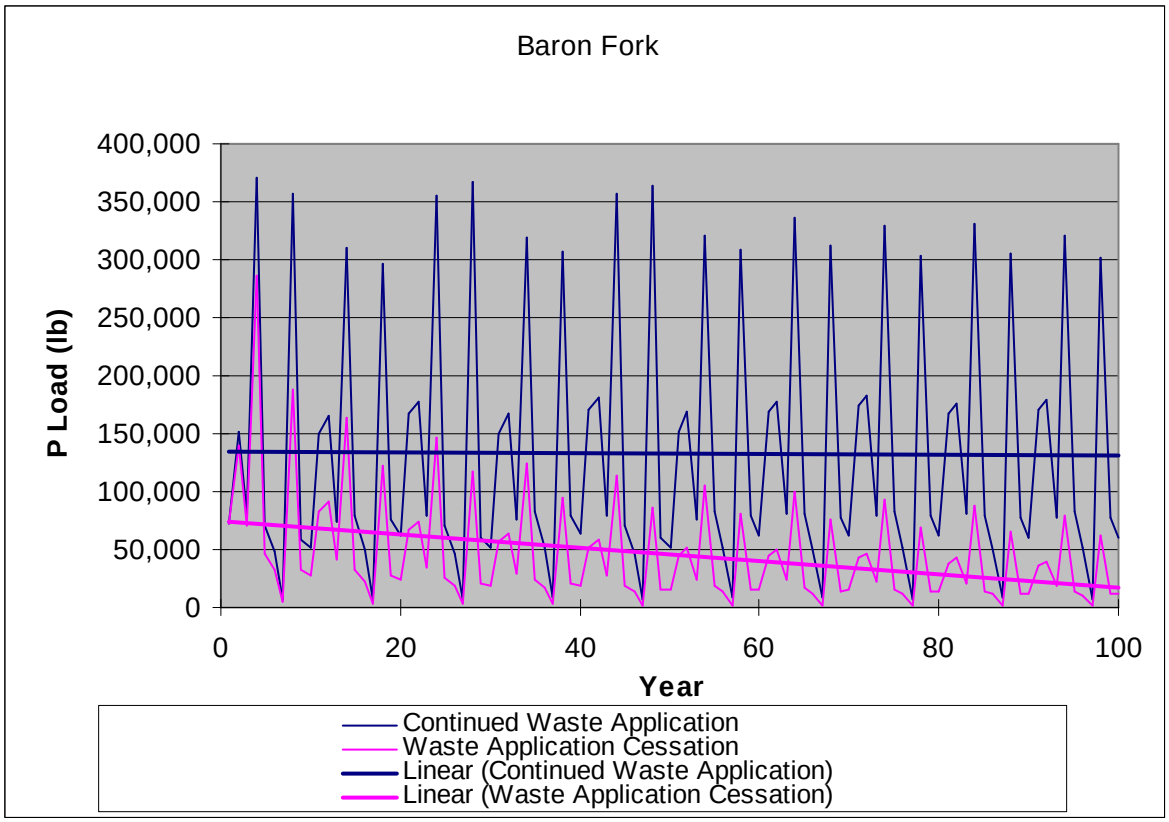

Figure 10.4. Modeled P Load at Baron Fork Gauging Station near Eldon for Continuing Poultry Waste Application and for Cessation of Poultry Waste Application in the IRW

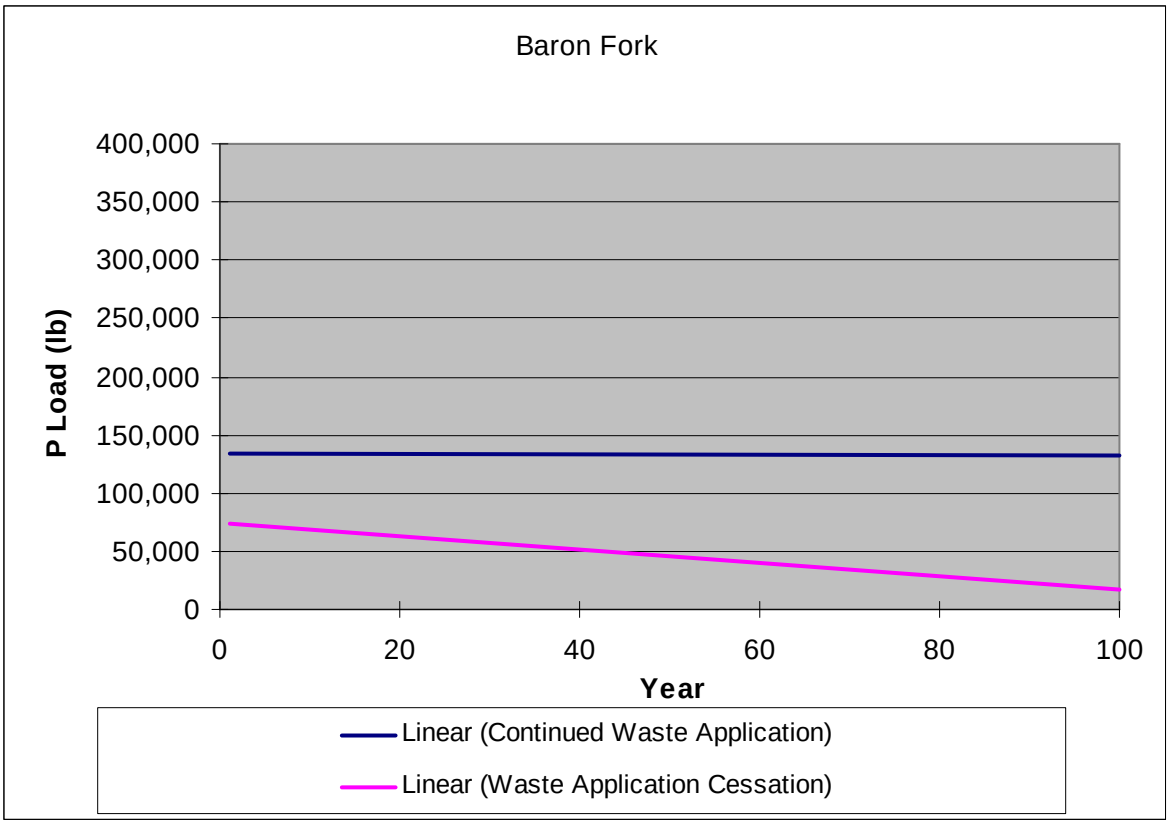

Figure 10.5. Trend Lines for Modeled P Load at Baron Fork Gauging Station Near Eldon for Continuing Poultry Waste Application and for Cessation of Poultry Waste Application in the IRW

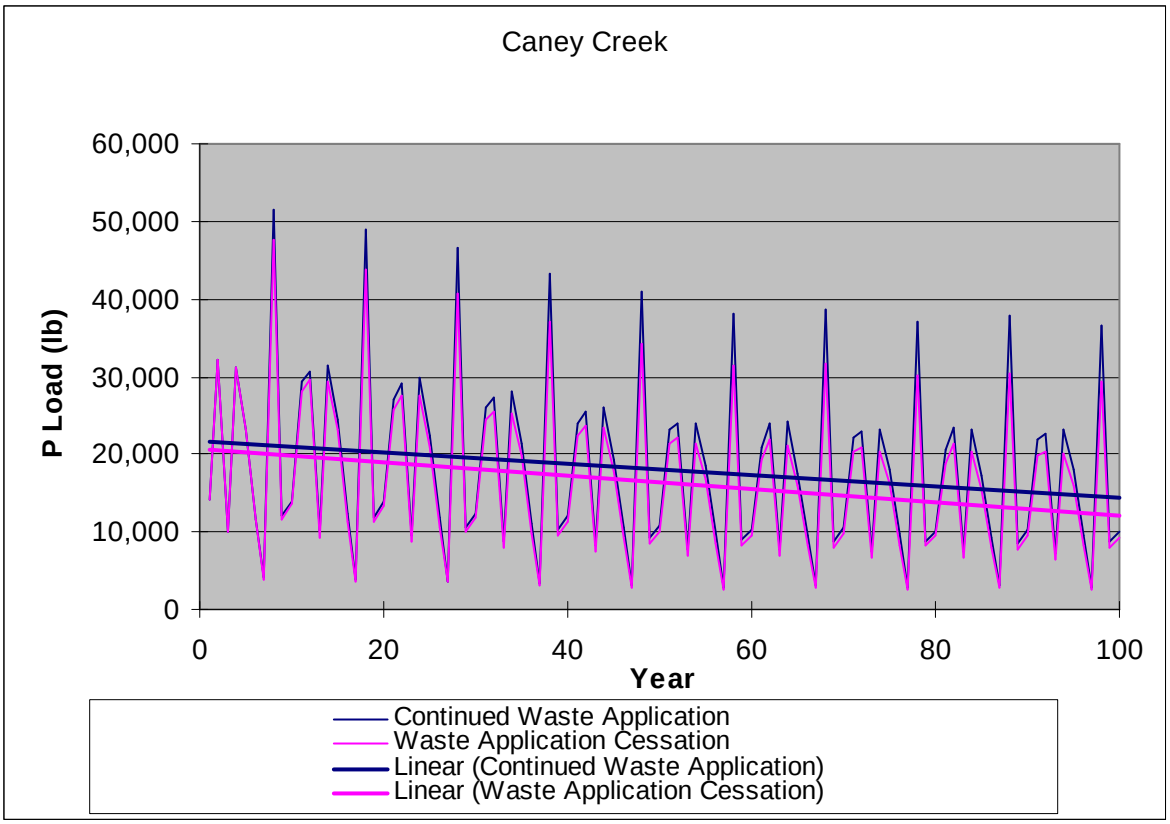

Figure 10.6. Modeled P Load at Caney Creek Gauging Station Near Eldon for Continuing Poultry Waste Application and for Cessation of Poultry Waste Application in the IRW

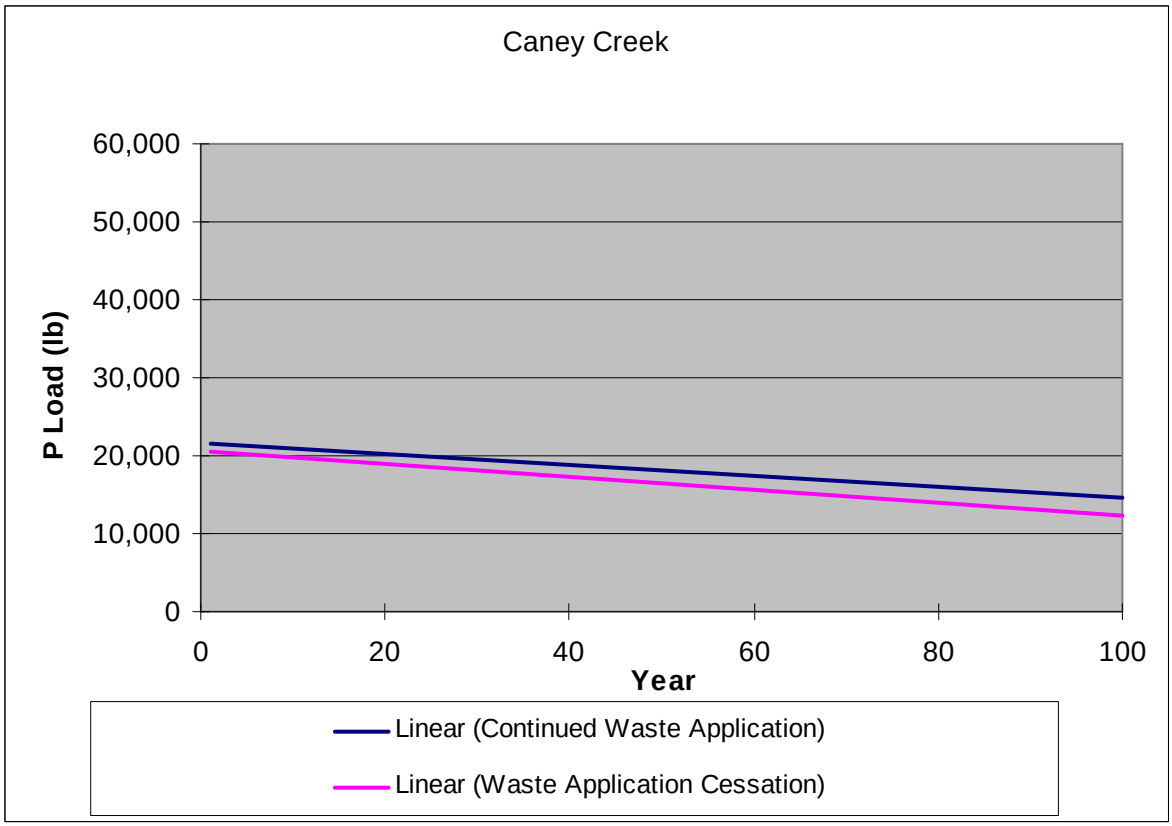

Figure 10.7. Trend Lines for Modeled P Load at Caney Creek Gauging Station near Eldon for Continuing Poultry Waste Application and for Cessation of Poultry Waste Application in the IRW

Table 10.2. Modeled P Loads at Illinois River Gauging Locations for Continued Poultry Waste Application and for Cessation of Waste Application in the IRW. Weather Repeats Every 10 Years So Results Are Summarized in 10 Year Periods.

	Illinois River at Tahlequah		**Baron Fork**		**Caney Creek**	
Years	P- Continued Waste Application (lb)	P – Cessation of Waste Application (lb)	P- Continued Waste Application (lb)	P – Cessation of Waste Application (lb)	P- Continued Waste Application (lb)	P – Cessation of Waste Application (lb)
1-10	3,822,825	3,228,076	1,270,773	902,718	203,842	199,023
11-20	4,339,792	2,883,964	1,271,226	612,367	216,495	202,985
21-30	4,382,776	2,470,734	1,381,747	526,205	202,723	187,090
31-40	4,332,982	2,171,050	1,305,641	451,979	191,549	174,504
41-50	4,300,436	1,956,417	1,385,702	404,085	177,873	160,049
51-60	4,262,743	1,807,808	1,309,606	373,561	167,480	149,083
61-70	4,277,709	1,718,007	1,357,290	354,406	164,823	145,315
71-80	4,265,243	1,641,867	1,351,562	330,728	162,631	143,212
81-90	4,266,819	1,586,264	1,336,545	305,908	161,113	141,031
91-100	4,275,583	1,537,452	1,328,482	285,075	160,397	139,876

Table 10.3. Change in P Loads to Lake Tenkiller for 10 Year Periods into the Future for Continued Poultry Waste Application and Cessation of Waste Application in the IRW. Weather Repeats Every 10 Years So Results Are Summarized in 10 Year Periods.

Year	Total P Continued Waste (lb)	Change from Previous 10 Years (%)	Total P Waste Cessation (lb)	Change from Previous 10 Years (%)
1-10	5297440		4329816	
11-20	5827513	10.0	3699316	-14.6
21-30	5967246	2.4	3184029	-13.9
31-40	5830172	-2.3	2797533	-12.1
41-50	5864011	0.6	2520552	-9.9
51-60	5739830	-2.1	2330452	-7.5
61-70	5799822	1.0	2217727	-4.8
71-80	5779435	-0.4	2115807	-4.6
81-90	5764477	-0.3	2033204	-3.9
91-100	5764462	0.0	1962403	-3.5

Table 10.4. Difference in P Loads to Tenkiller for Continued Poultry Waste Application Compared to Poultry Waste Application Cessation. Weather Repeats Every 10 Years So Results Are Summarized in 10 Year Periods.

Year	Total P Continued Waste (lb)	Total P Waste Cessation (lb)	Difference (%)
1-10	5,297,440	4,329,816	18.3
11-20	5,827,513	3,699,316	36.5
21-30	5,967,246	3,184,029	46.6
31-40	5,830,172	2,797,533	52.0
41-50	5,864,011	2,520,552	57.0
51-60	5,739,830	2,330,452	59.4
61-70	5,799,822	2,217,727	61.8
71-80	5,779,435	2,115,807	63.4
81-90	5,764,477	2,033,204	64.7
91-100	5,764,462	1,962,403	66.0

Table 10.5. Percentage Change in Modeled P Loads Relative to Modeled P Between 1997-2006 at Illinois River Gauging Locations for Continued Waste Application and Moratorium on Waste Application. Weather Repeats Every 10 Years So Results Are Summarized in 10 Year Periods.

	Illinois River at Tahlequah		**Baron Fork**		**Caney Creek**	
Year	P Continue Waste (%)	P Stop Waste (%)	P Continue Waste (%)	P Stop Waste (%)	P Continue Waste (%)	P Stop Waste (%)
1-10	4.0	-12.2	30.7	-7.1	-2.6	-4.9
11-20	18.0	-21.6	30.8	-37.0	3.4	-3.0
21-30	19.2	-32.8	42.2	-45.9	-3.2	-10.6
31-40	17.8	-41.0	34.3	-53.5	-8.5	-16.7
41-50	16.9	-46.8	42.6	-58.4	-15.0	-23.6
51-60	15.9	-50.8	34.7	-61.6	-20.0	-28.8
61-70	16.3	-53.3	39.7	-63.5	-21.3	-30.6
71-80	16.0	-55.4	39.1	-66.0	-22.3	-31.6
81-90	16.0	-56.9	37.5	-68.5	-23.0	-32.6
91-100	16.3	-58.2	36.7	-70.7	-23.4	-33.2

Table 10.6. Percentage Change in Modeled P Loads Relative to Observed P Between 1997-2006 at Illinois River Gauging Locations for Continued Waste Application and Cessation of Waste Application. Weather Repeats Every 10 Years So Results Are Summarized in 10 Year Periods.

	Illinois River at Tahlequah		**Baron Fork**		**Caney Creek**	
Year	P – Continued Waste (%)	P – Waste Cessation (%)	P – Continued Waste (%)	P – Waste Cessation (%)	P – Continued Waste (%)	P – Waste Cessation (%)
1-10	4.2	-12.0	9.4	-22.3	-5.5	-7.7
11-20	18.3	-21.4	9.5	-47.3	0.4	-5.9
21-30	19.4	-32.7	19.0	-54.7	-6.0	-13.2
31-40	18.1	-40.8	12.4	-61.1	-11.2	-19.1
41-50	17.2	-46.7	19.3	-65.2	-17.5	-25.8
51-60	16.2	-50.7	12.8	-67.8	-22.3	-30.9
61-70	16.6	-53.2	16.9	-69.5	-23.6	-32.6
71-80	16.2	-55.3	16.4	-71.5	-24.6	-33.6
81-90	16.3	-56.8	15.1	-73.7	-25.3	-34.6
91-100	16.5	-58.1	14.4	-75.4	-25.6	-35.1

For continued poultry waste application, the P loads at Tahlequah increase slightly for the first 30 years before stabilizing in subsequent years. Thus, the trend line for P loads at Tahlequah is nearly flat.

The P loads decrease by more than 18% in the first 10 years for IRW poultry waste application cessation compared to continued poultry waste application (Table 10.4 and Figure 10.8). The results indicate that poultry waste land application cessation within the IRW would provide some benefit (18% reduction in P loads to Lake Tenkiller). However, between 30-40 years would be required for the P loads to be reduced to 50% of their current levels and more than 60 years for them to be reduced by more than 60%.

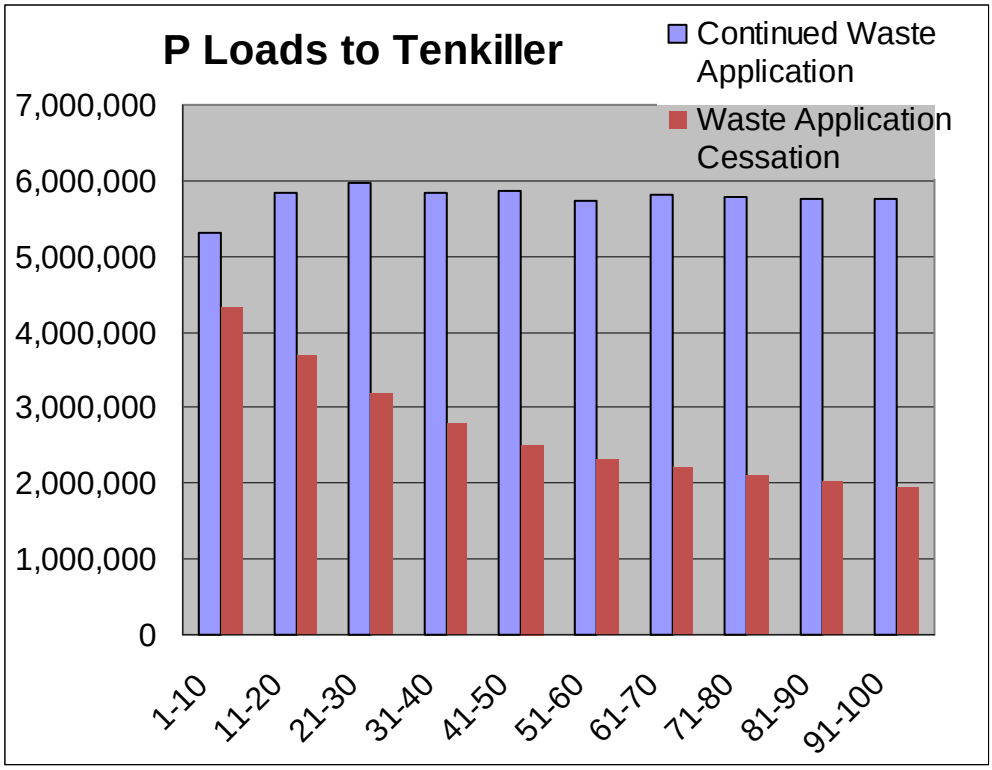

Figure 10.8. P Loads to Lake Tenkiller for Continued Waste Application in the IRW. Weather Repeats Every 10 Years So Results Are Summarized in 10 Year Periods.

10.3 P Loads for Increased Poultry Waste Application

For continued growth in the IRW poultry industry at a rate the same as that between 1982 and 2002, P loads to Lake Tenkiller would increase substantially. Within 40-50 years, P loads to Lake Tenkiller would increase substantially (increase of 70%).

Based on this rate of growth assumption, P loads to Lake Tenkiller through the Tahlequah location would increase substantially (increase by 79% in 40-50 years) as a result of increased poultry waste application in this watershed. P load changes at the Baron Fork location would increase by more than 92% in 40-50 years.

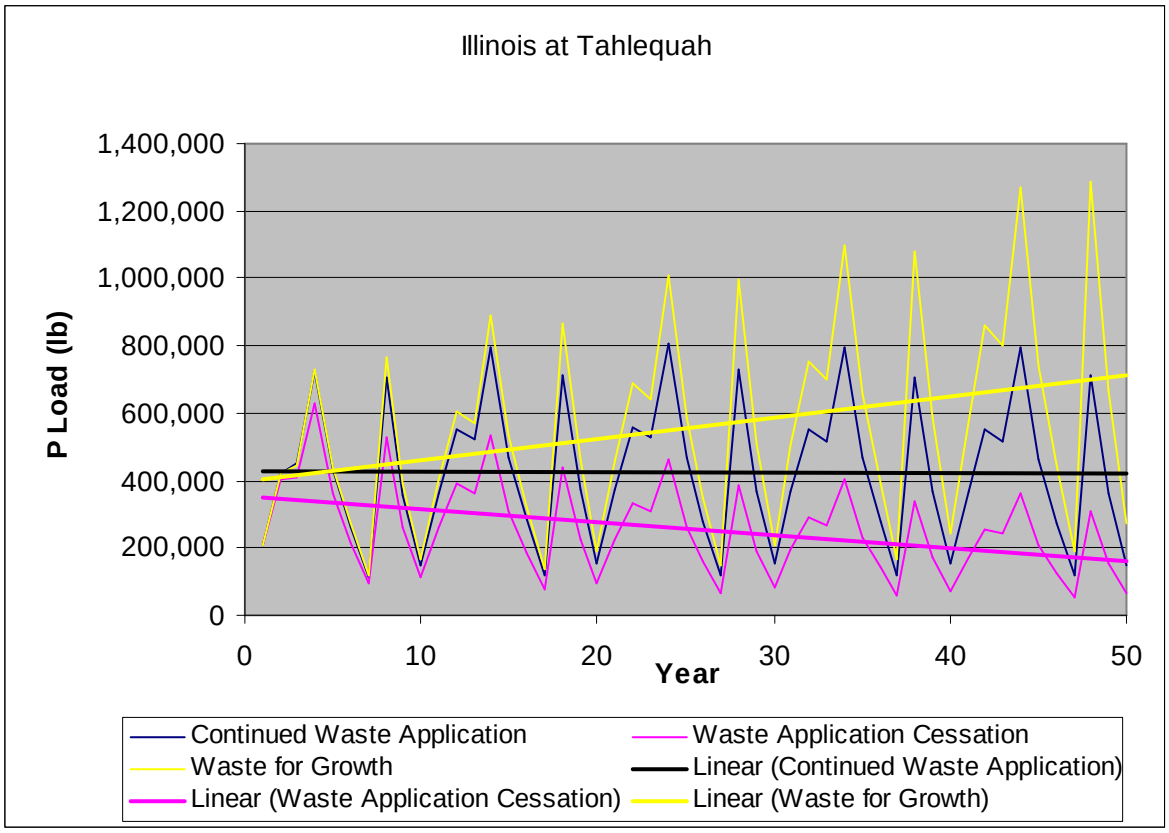

Figure 10.9. P Loading and Trend Lines at Tahlequah for Continued Waste Application, Waste Application Cessation, and Growth in Waste Application Modeled after Poultry Growth in IRW between 1982 and 2002 Based on Ag Census Data

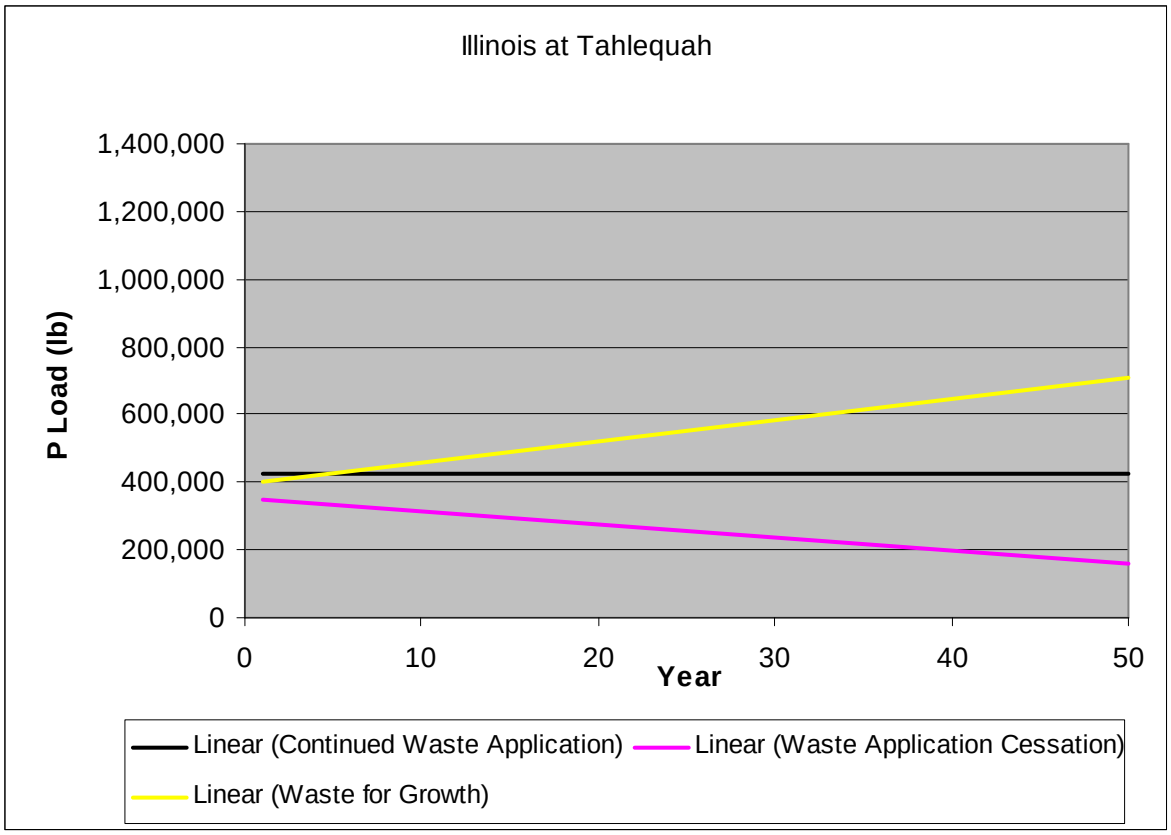

Figure 10.10. P Loading Trend Lines at Tahlequah for Continued Waste Application, Waste Application Cessation, and Growth in Waste Application Modeled after Poultry Growth in IRW between 1982 and 2002 Based on Ag Census Data

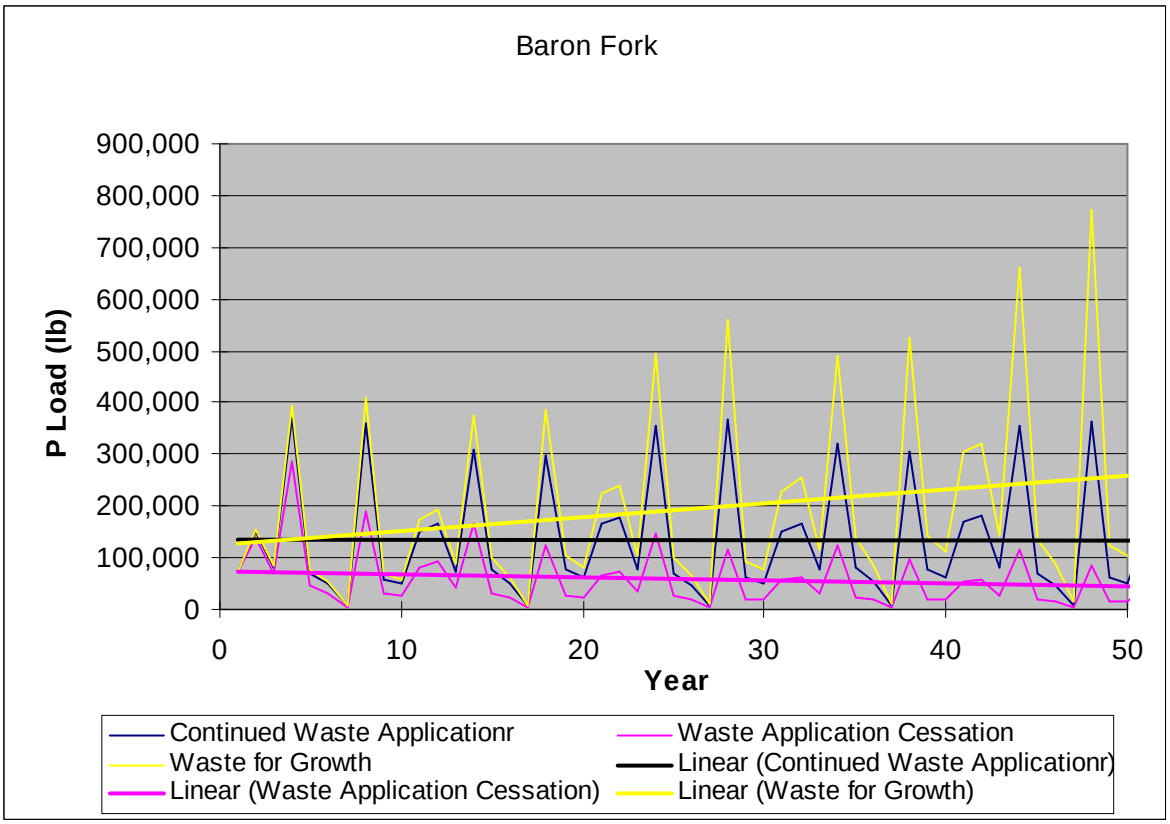

Figure 10.11. P Load and Trend Lines at Baron Fork near Eldon for Continued Waste Application, Waste Application Cessation, and Growth in Waste Application Modeled after Poultry Growth in IRW between 1982 and 2002 Based on Ag Census Data

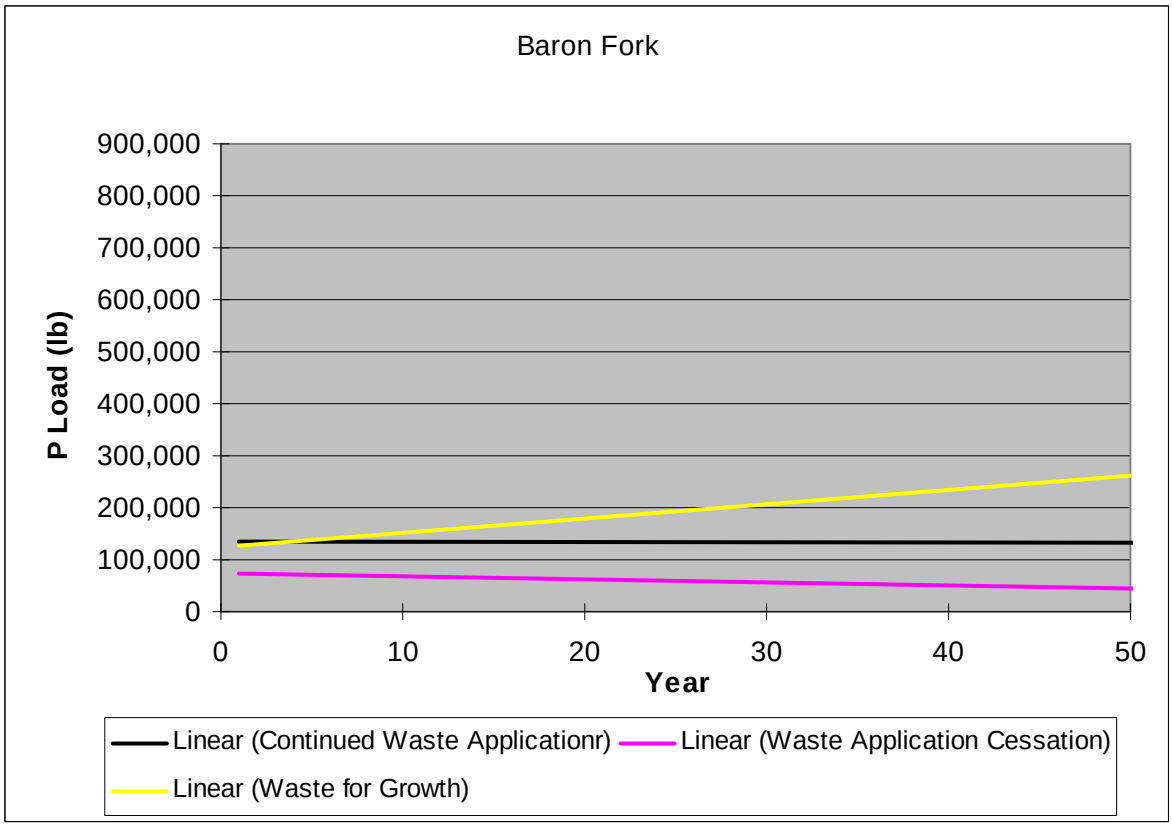

Figure 10.12. P Load Trend Lines at Baron Fork near Eldon for Continued Waste Application, Waste Application Cessation, and Growth in Waste Application Modeled after Poultry Growth in IRW between 1982 and 2002 Based on Ag Census Data

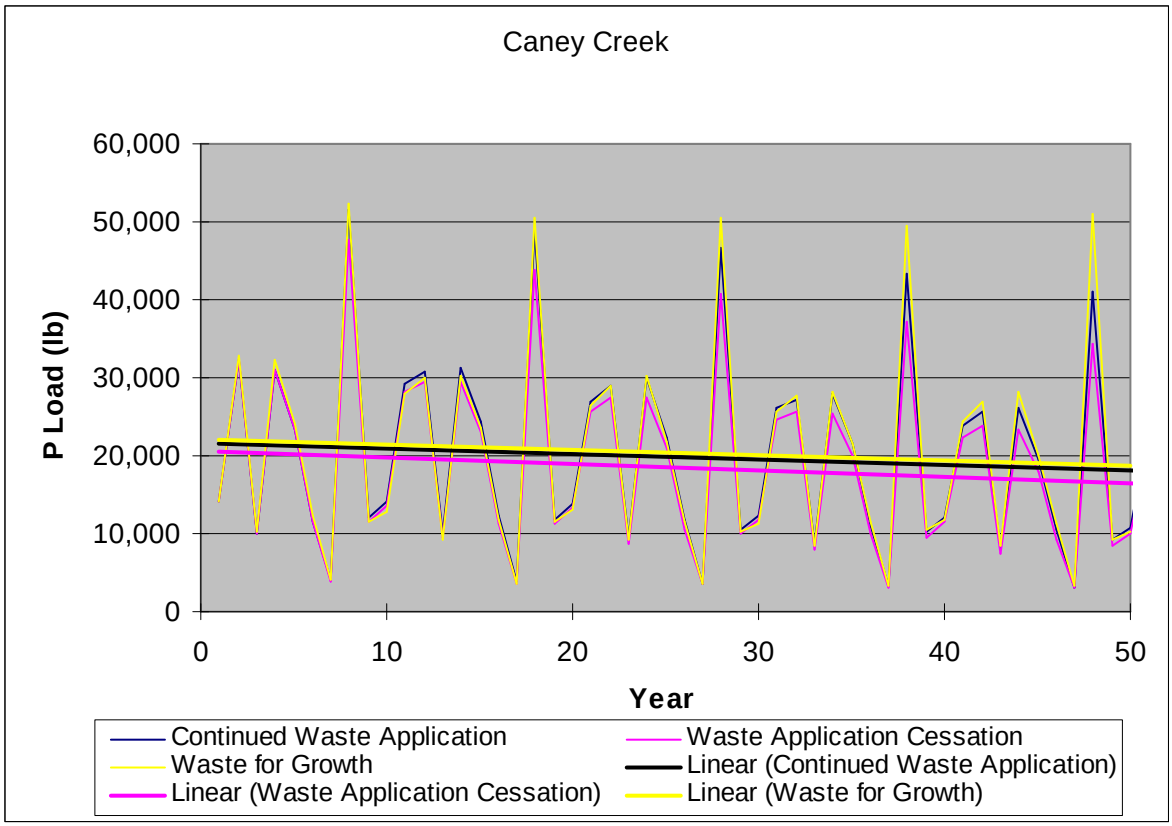

Figure 10.13. P Load and Trend Lines at Caney Creek for Continued Waste Application, Waste Application Cessation and Growth in Waste Application Modeled after Poultry Growth in IRW between 1982 and 2002 Based on Ag Census Data

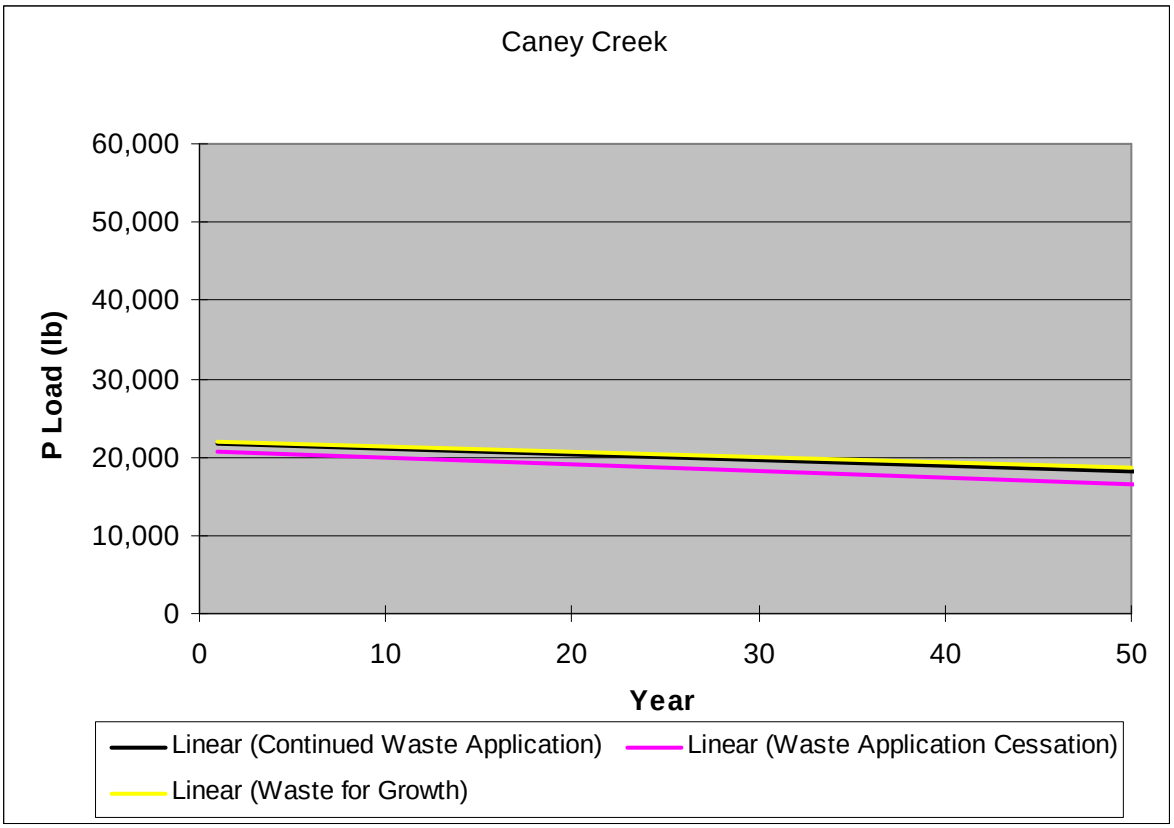

Figure 10.14. P Load Trend Lines at Caney Creek for Continued Waste Application, Waste Application Cessation and Growth in Waste Application Modeled after Poultry Growth in IRW between 1982 and 2002 Based on Ag Census Data

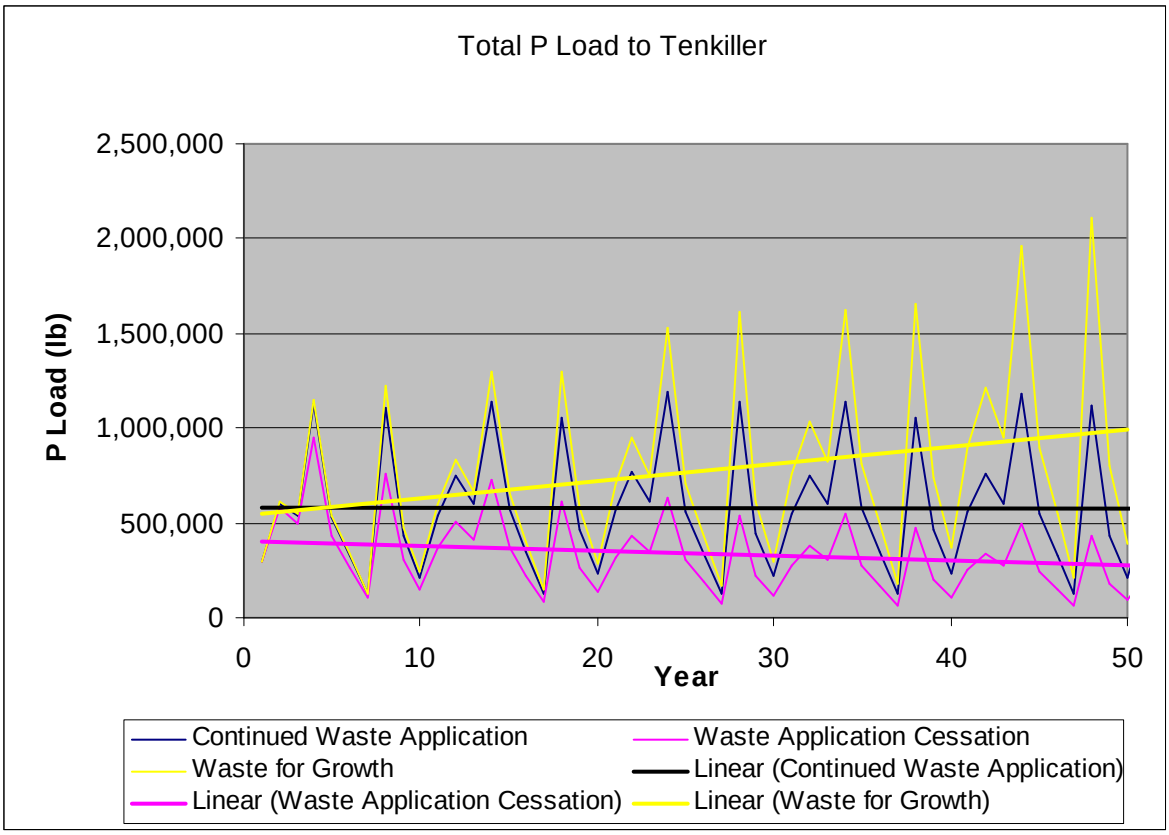

Figure 10.15. P Load and Trend Lines to Lake Tenkiller for Continued Waste Application, Waste Application Cessation and Growth in Waste Application Modeled after Poultry Growth in IRW between 1982 and 2002 Based on Ag Census Data

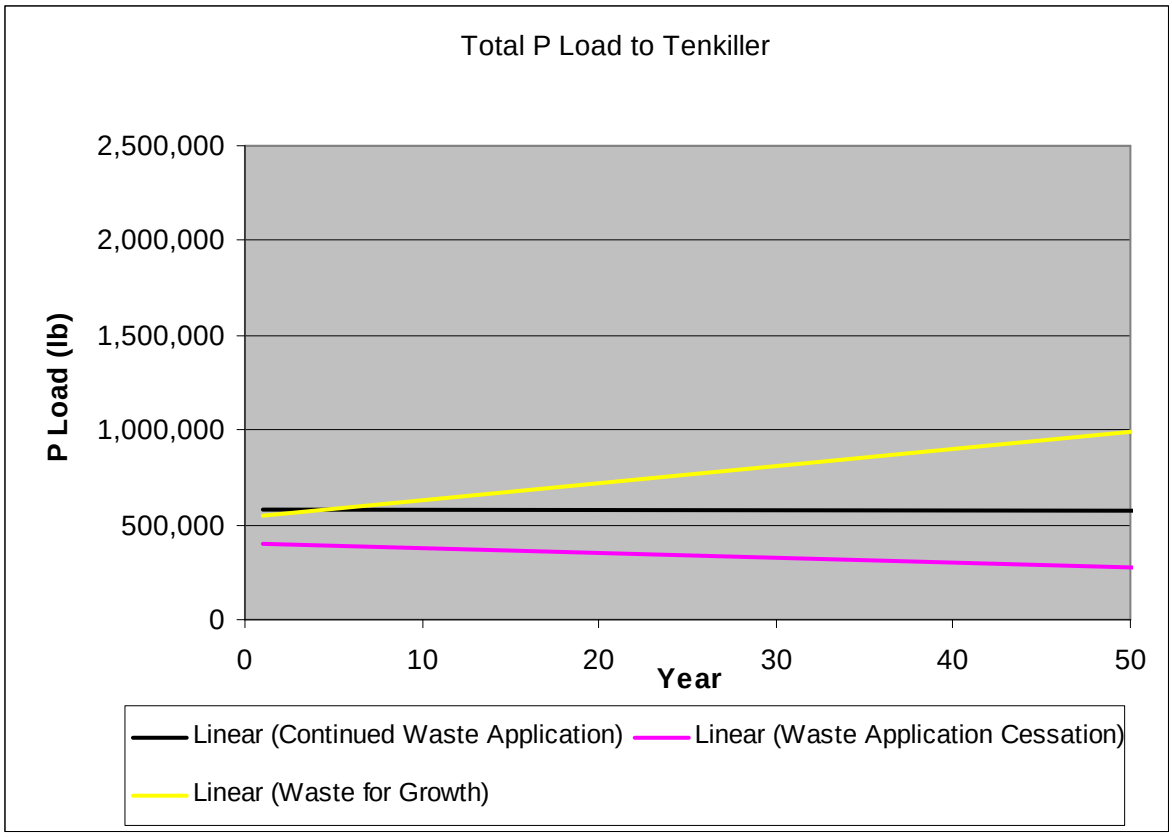

Figure 10.16. P Load Trend Lines to Lake Tenkiller for Continued Waste Application, Waste Application Cessation and Growth in Waste Application Modeled after Poultry Growth in IRW between 1982 and 2002 Based on Ag Census Data

Table 10.7. P Loads for Growth in IRW Poultry Compared to P Load for Poultry Waste Applied to IRW at Current Rates. Weather Repeats Every 10 Years So Results Are Summarized in 10 Year Periods.

	P Load (lb) for Growth in Poultry in IRW				**P Load (lb)**	
Years	Tahlequah	Baron Fork	Caney	Total	Total Continued Waste	Increase (%)
1-10	3,957,714	1,383,326	206,764	5,547,804	5,496,292	0.9
11-20	4,977,804	1,577,487	211,913	6,767,204	5,863,724	15.4
21-30	5,601,473	1,968,858	204,190	7,774,521	5,956,205	30.5
31-40	6,183,185	2,108,278	197,950	8,489,412	5,834,827	45.5
41-50	7,098,538	2,670,601	193,049	9,962,188	5,854,425	70.2

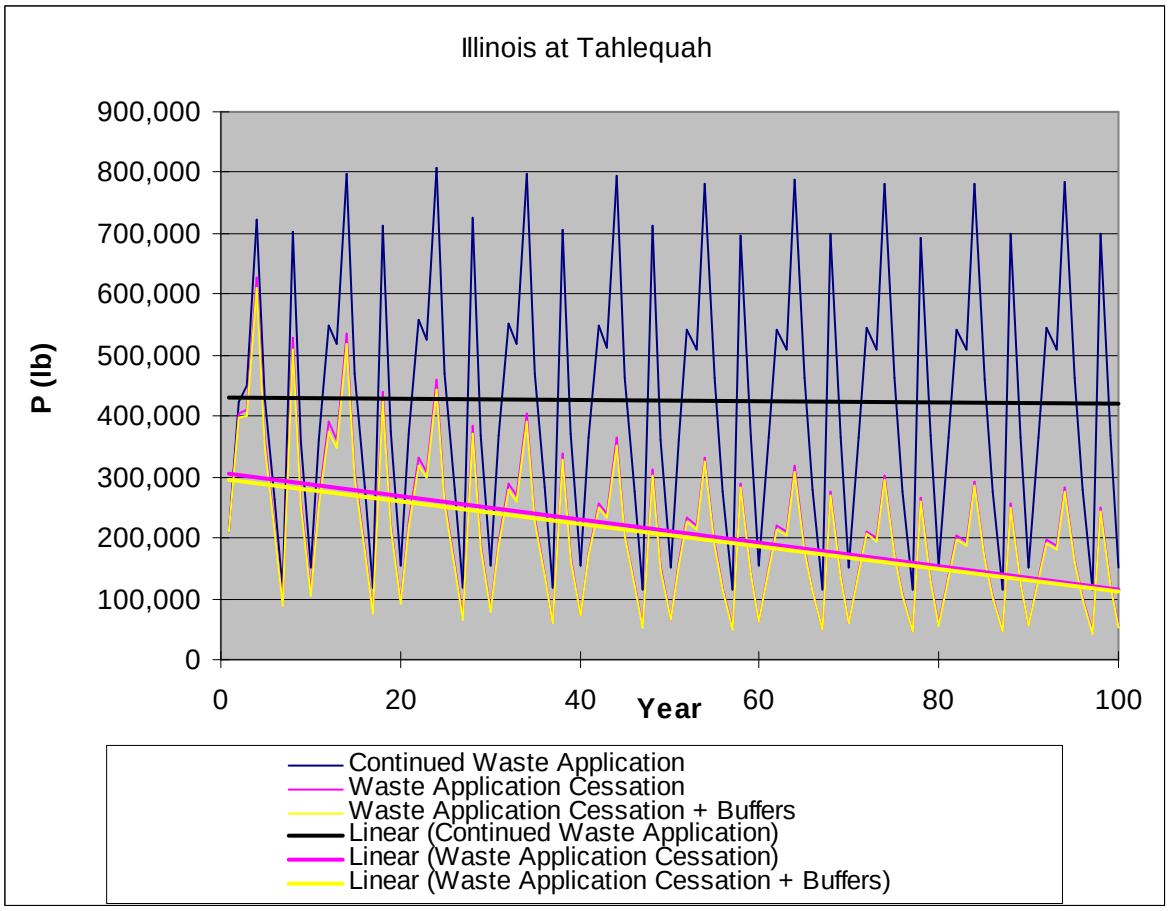

Figure 10.17. P Loads at Tahlequah for the Combination of Buffers Along Third Order and Larger Streams and Rivers and Poultry Waste Land Application Cessation in the IRW.

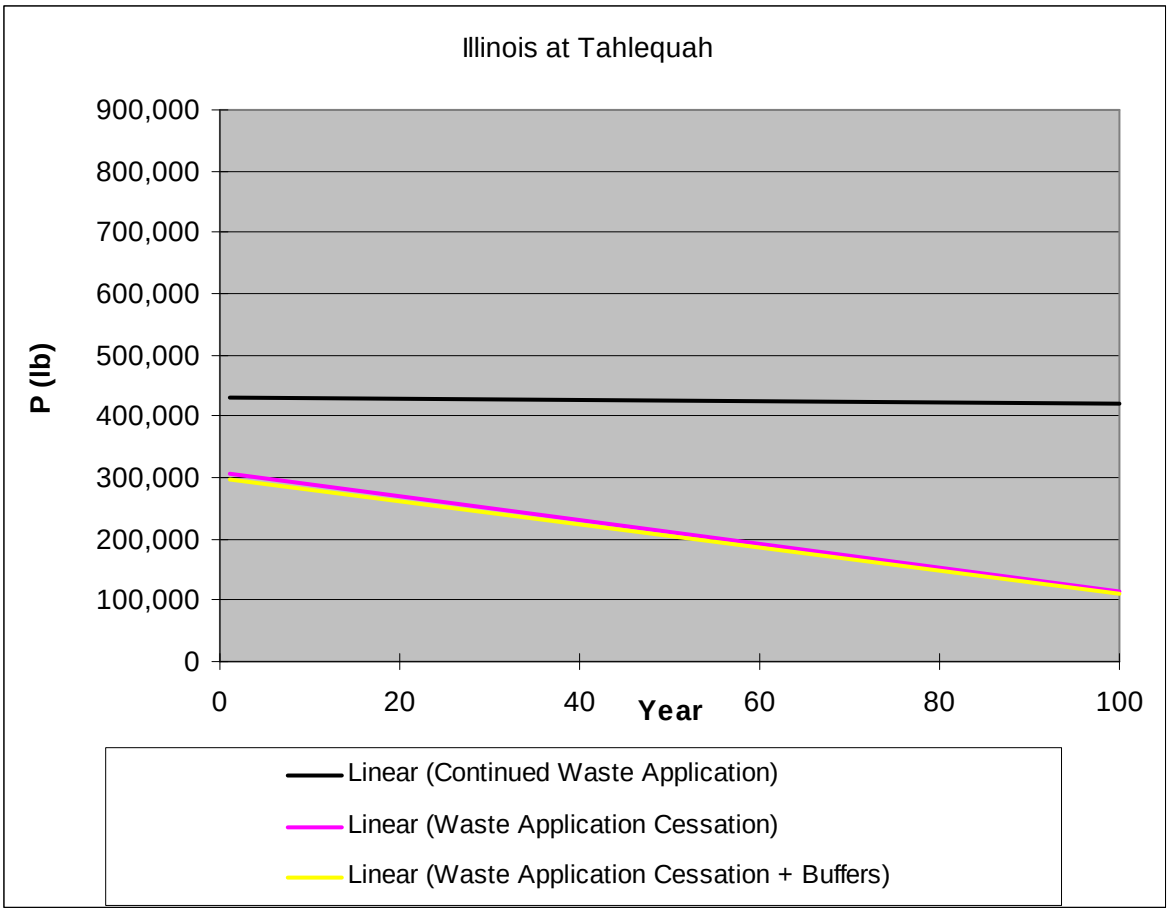

Figure 10.18. P Load Trend Lines at Tahlequah for the Combination of Buffers Along Third Order and Larger Streams and Rivers and Poultry Waste Land Application Cessation in the IRW.

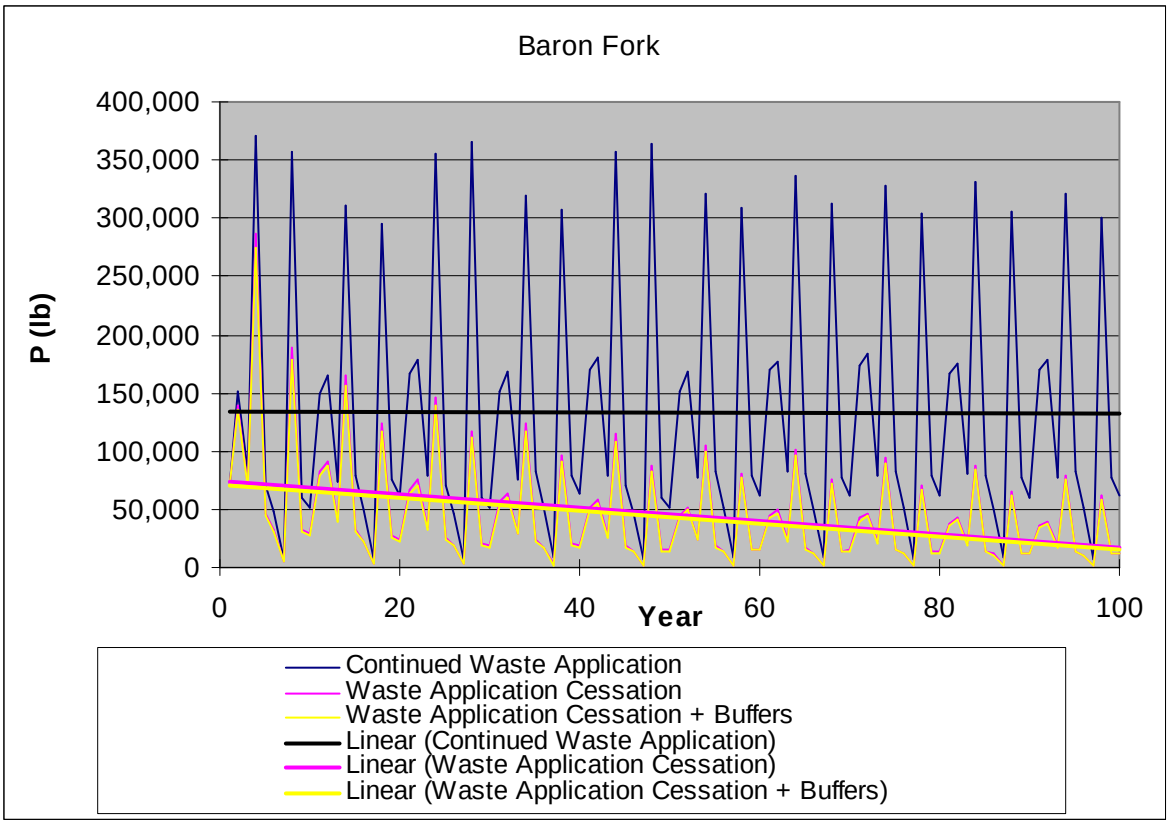

Figure 10.19. P Loads at Baron Fork Near Eldon for the Combination of Buffers Along Third Order and Larger Streams and Rivers and Poultry Waste Land Application Cessation in the IRW.

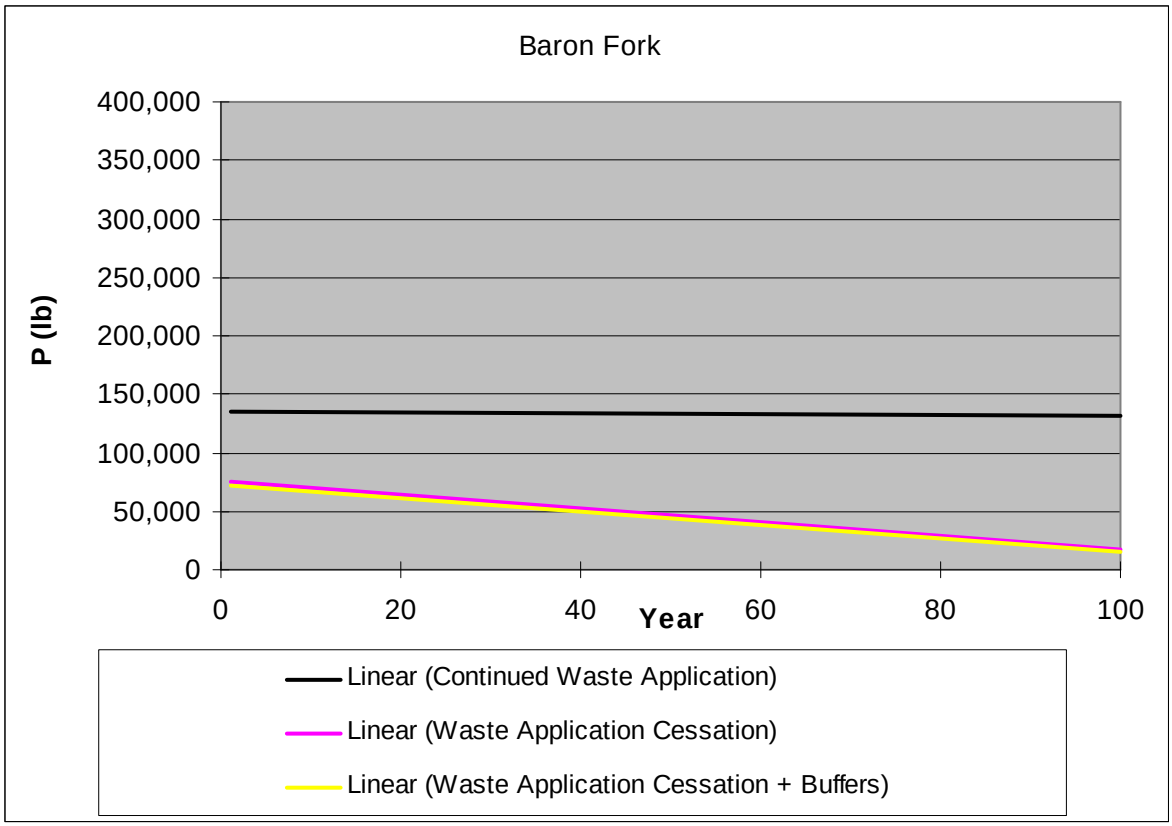

Figure 10.20. P Load Trend Lines at Baron Fork Near Eldon for the Combination of Buffers Along Third Order and Larger Streams and Rivers and Poultry Waste Land Application Cessation in the IRW.

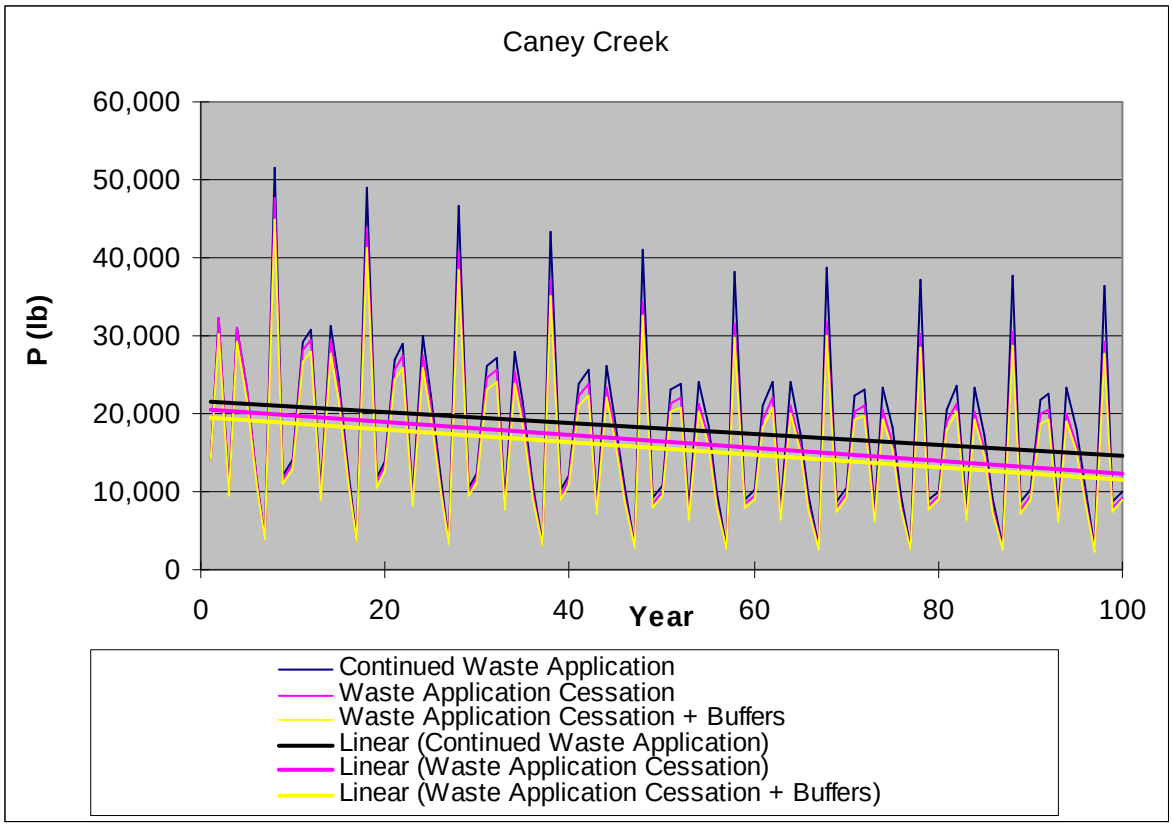

Figure 10.21. P Loads at Caney Creek for the Combination of Buffers Along Third Order and Larger Streams and Rivers and Poultry Waste Land Application Cessation in the IRW.

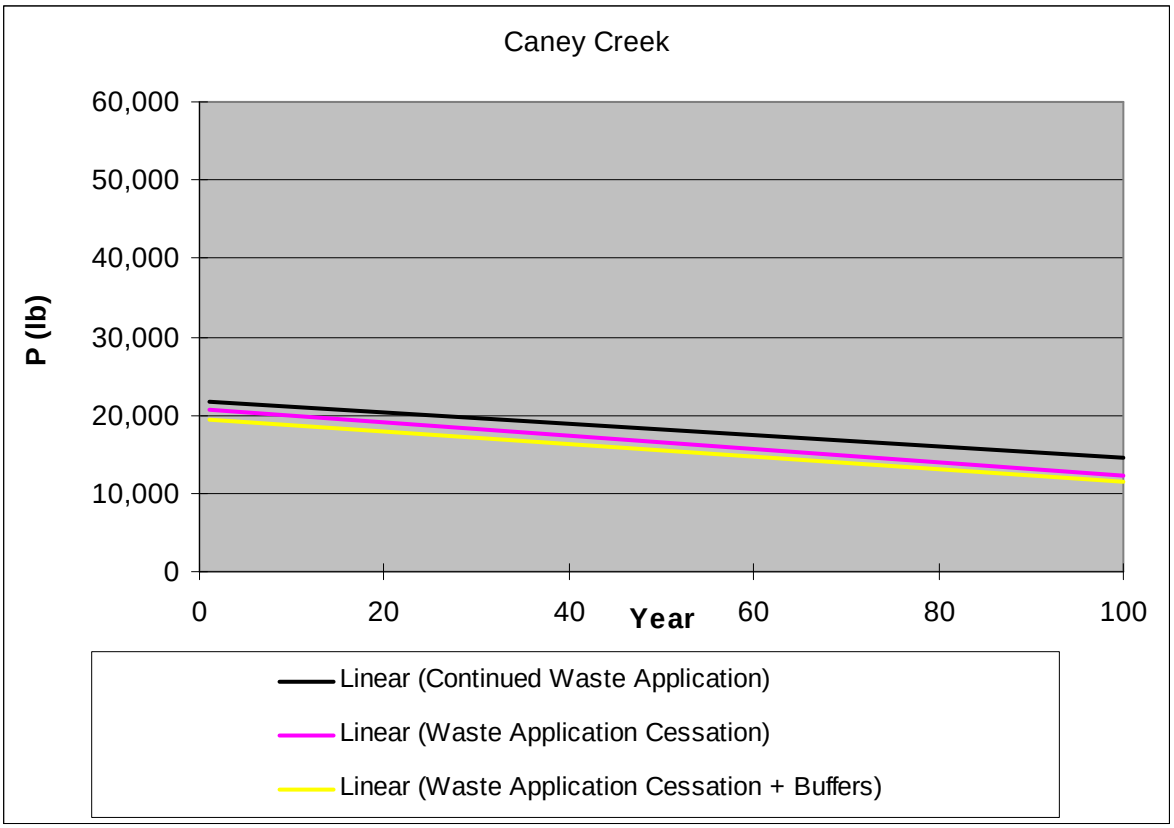

Figure 10.22. P Load Trends at Caney Creek for the Combination of Buffers Along Third Order and Larger Streams and Rivers and Poultry Waste Land Application Cessation in the IRW.

Table 10.8. P Loads for Poultry Waste Cessation and Poultry Waste Cessation Combined with Buffers Along Third Order and Larger Streams in the IRW. Weather Repeats Every 10 Years So Results Are Summarized in 10 Year Periods.

	P Loads (lbs)					
Years	Tahlequah	Baron	Caney	Total	Total (Cessation Only)	Buffer Reduction (%)
1-10	3,139,909	865,488	188,541	4,193,938	4,535,255	7.5
11-20	2,782,118	582,364	191,677	3,556,159	3,707,475	4.1
21-30	2,387,730	500,622	176,719	3,065,071	3,164,230	3.1
31-40	2,103,258	430,222	164,883	2,698,363	2,784,794	3.1
41-50	1,899,641	384,791	151,280	2,435,712	2,512,765	3.1
51-60	1,758,669	355,841	140,965	2,255,475	2,323,273	2.9
61-70	1,673,470	337,674	137,422	2,148,566	2,213,865	2.9
71-80	1,601,255	315,212	135,439	2,051,906	2,113,394	2.9
81-90	1,548,513	291,674	133,392	1,973,579	2,032,222	2.9
91-100	1,502,205	271,911	132,301	1,906,417	1,961,163	2.8

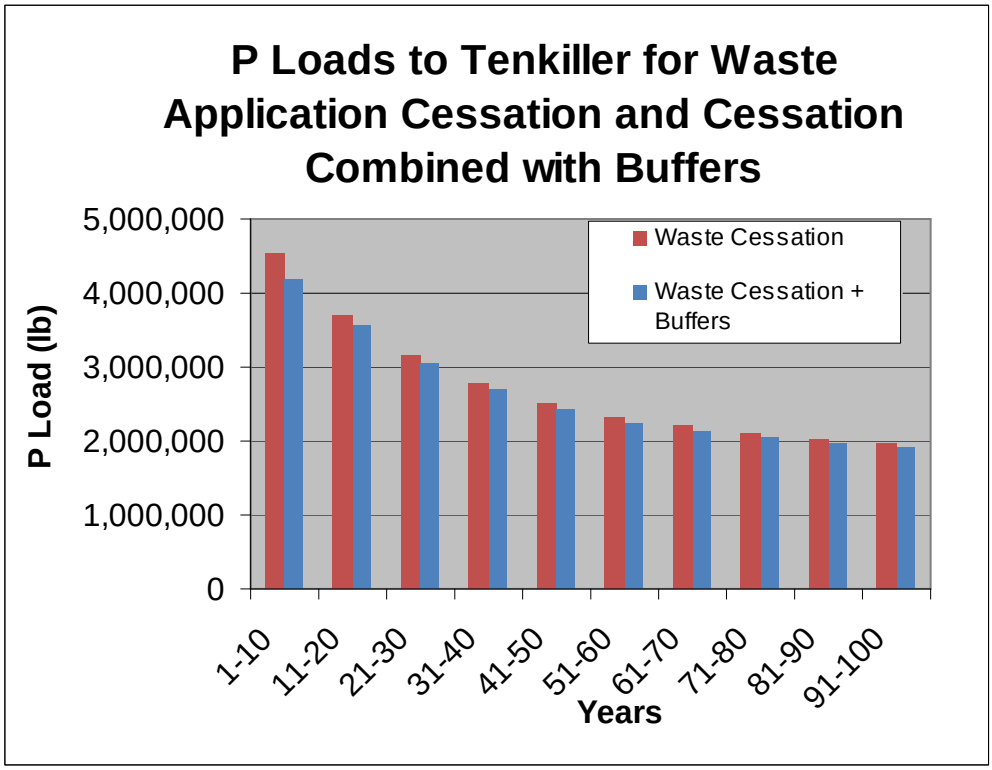

Figure 10.23. P Loads to Lake Tenkiller for Poultry Waste Application Cessation and Cessation Combined with Buffers Along Third Order Streams with Pastures. Weather Repeats Every 10 Years So Results Are Summarized in 10 Year Periods.

Table 10.9. P Loads for Poultry Waste Cessation and Poultry Waste Cessation Combined with Buffers Along *All Streams* with Pasture in the IRW. Weather Repeats Every 10 Years So Results Are Summarized in 10 Year Periods.

	P Load (lbs)					
Years	Tahlequah	Baron	Caney	Total	Total (Cessation Only)	Buffer Reduction (%)
1-10	2,944,473	782,950	165,369	3,892,792	4,535,255	14.2
11-20	2,556,846	516,237	166,704	3,239,788	3,707,475	12.6
21-30	2,204,159	444,237	153,816	2,802,213	3,164,230	11.4
31-40	1,953,332	382,272	143,635	2,479,239	2,784,794	11.0
41-50	1,774,078	342,267	131,913	2,248,258	2,512,765	10.5
51-60	1,649,995	316,786	123,037	2,089,818	2,323,273	10.0
61-70	1,574,976	300,798	119,991	1,995,765	2,213,865	9.9
71-80	1,511,440	281,014	118,275	1,910,729	2,113,394	9.6
81-90	1,465,023	260,303	116,522	1,841,847	2,032,222	9.4
91-100	1,424,252	242,897	115,574	1,782,724	1,961,163	9.1

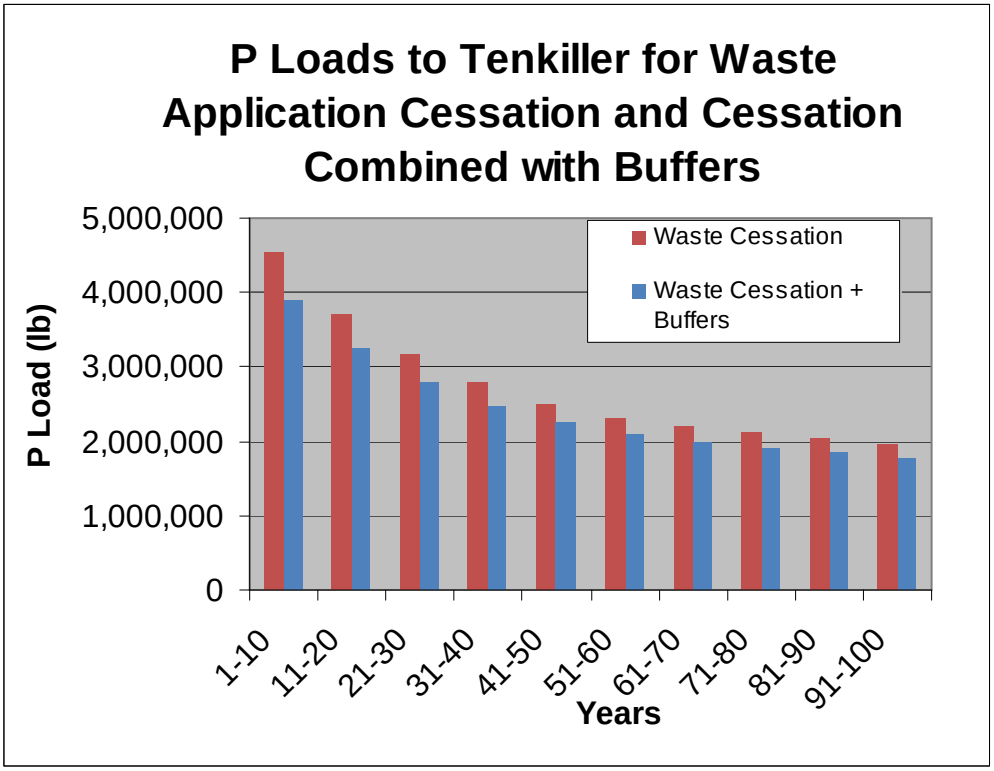

Figure 10.24. P Loads to Lake Tenkiller for Poultry Waste Application Cessation and Cessation Combined with Buffers Along *All Streams* with Pastures. Weather Repeats Every 10 Years So Results Are Summarized in 10 Year Periods.

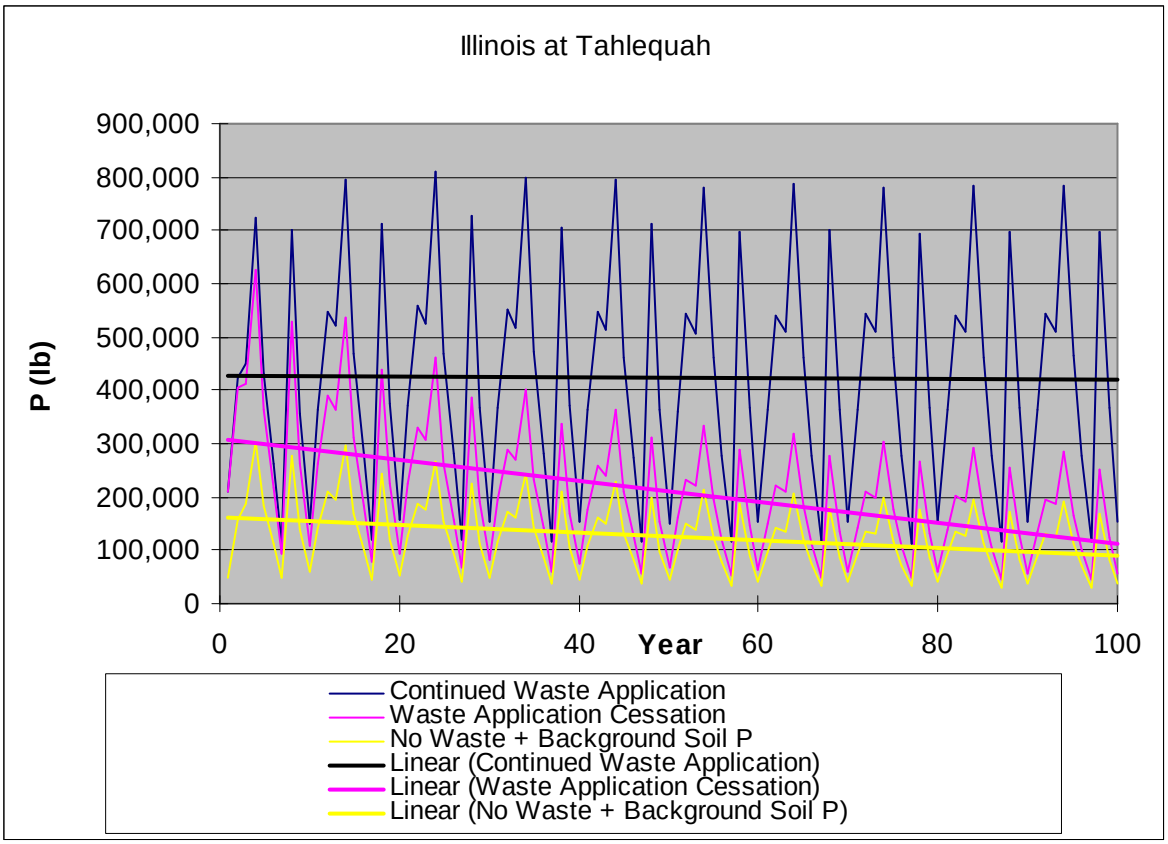

Figure 10.25. P Loads at Tahlequah for Background Soil P Levels with No Poultry Waste Application in the IRW.

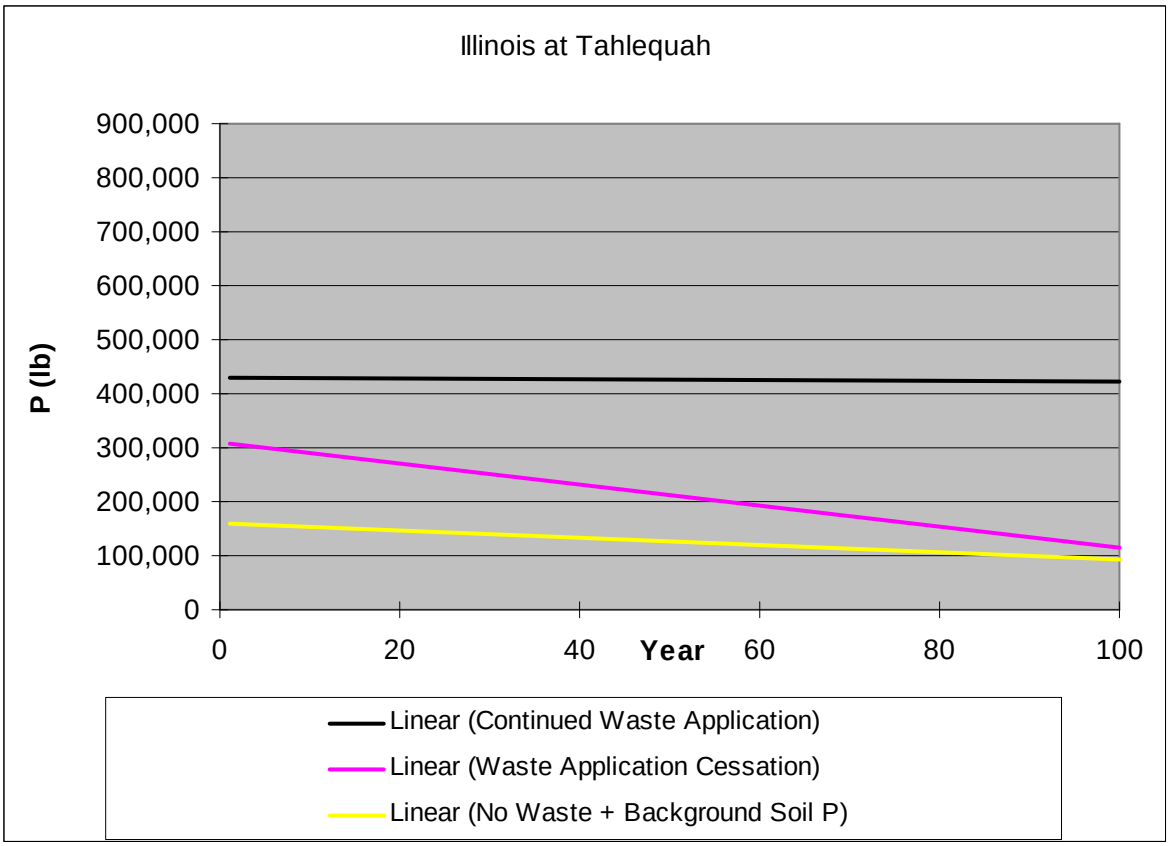

Figure 10.26. P Load Trend at Tahlequah for Background Soil P Levels with No Poultry Waste Application in the IRW.

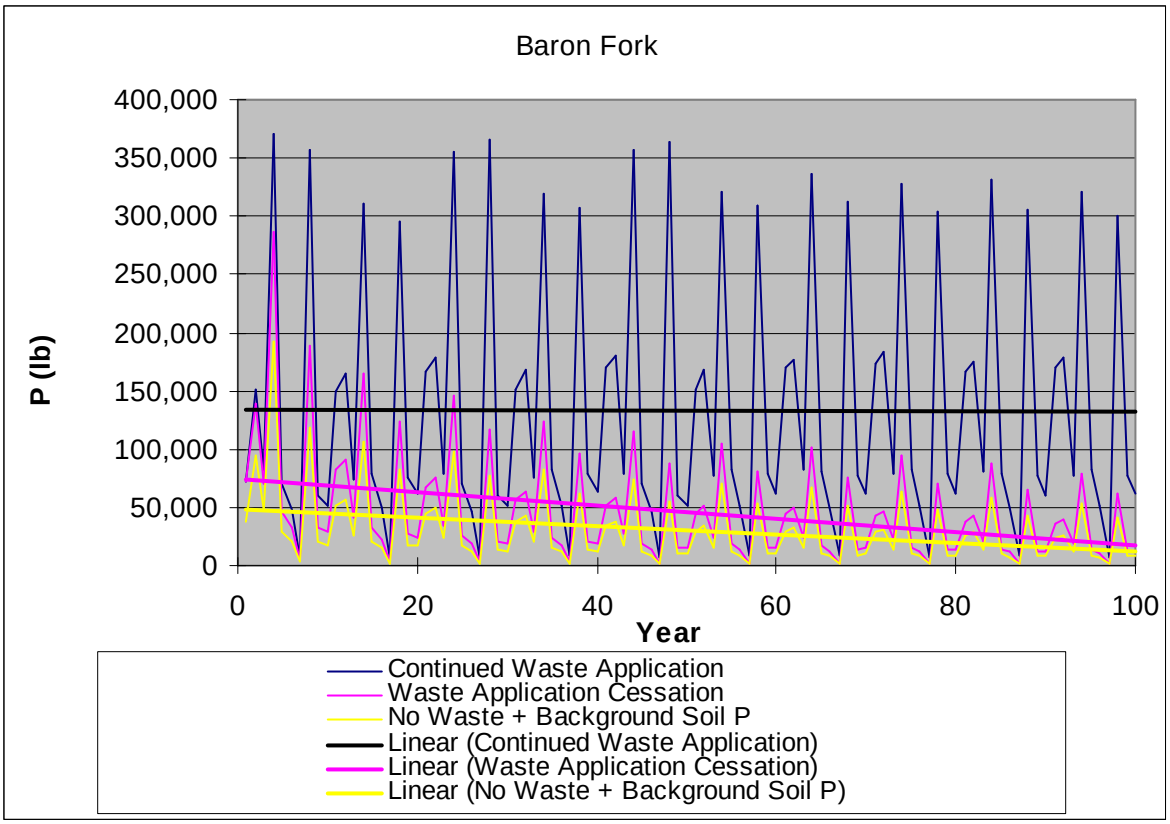

Figure 10.27. P Loads at Baron Fork near Eldon for Background Soil P Levels with No Poultry Waste Application in the IRW.

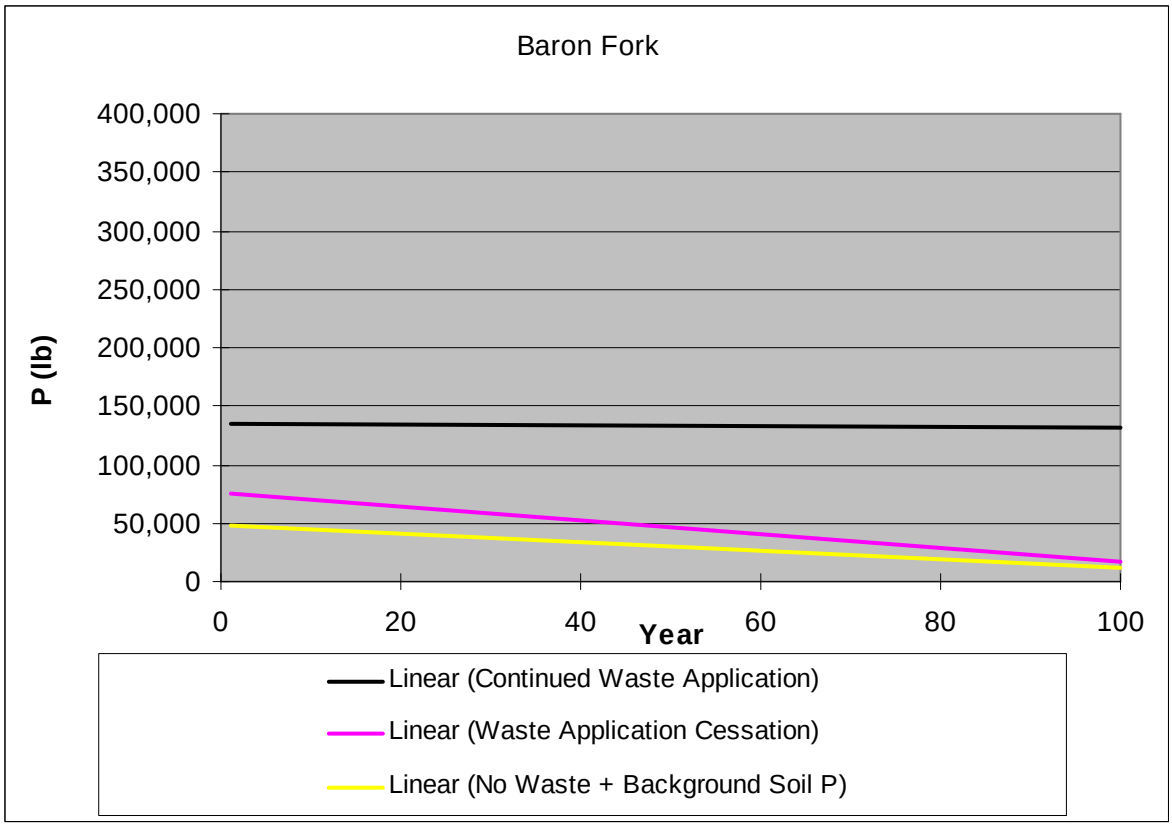

Figure 10.28. P Load Trend at Baron Fork near Eldon for Background Soil P Levels with No Poultry Waste Application in the IRW.

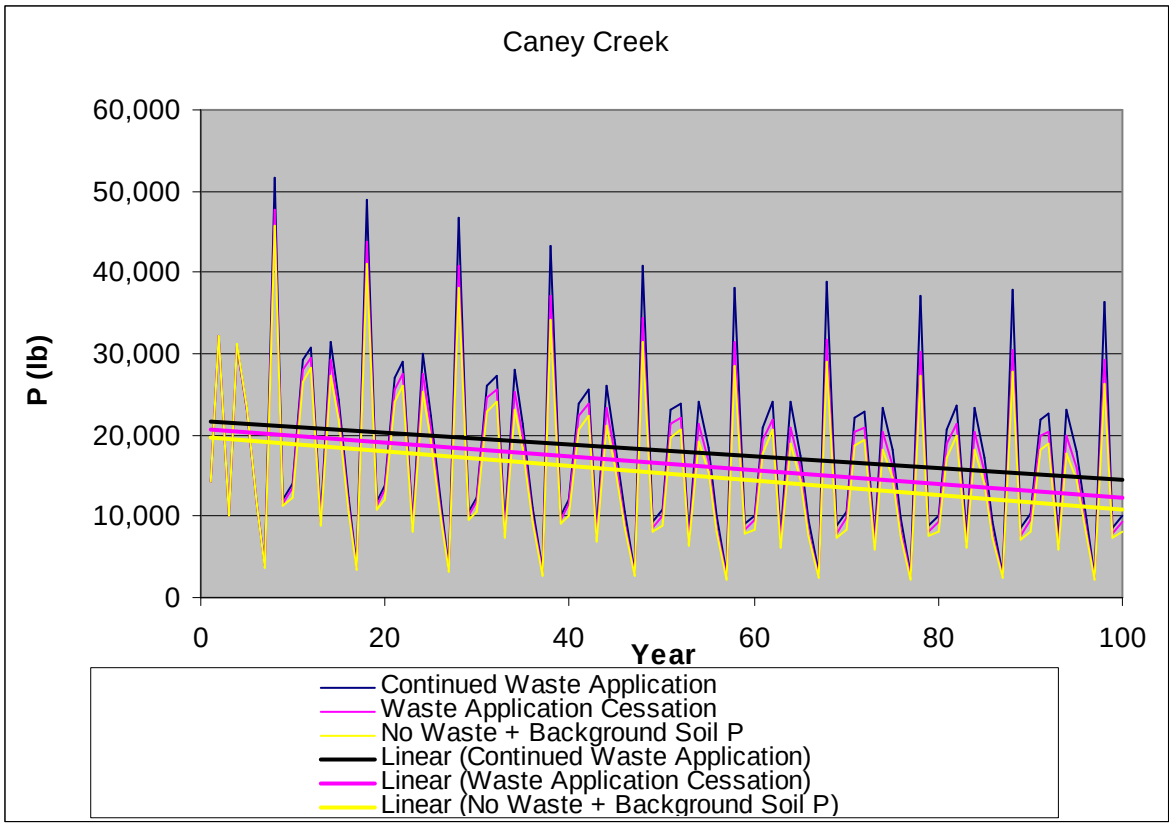

Figure 10.29. P Loads at Caney Creek for Background Soil P Levels with No Poultry Waste Application in the IRW.

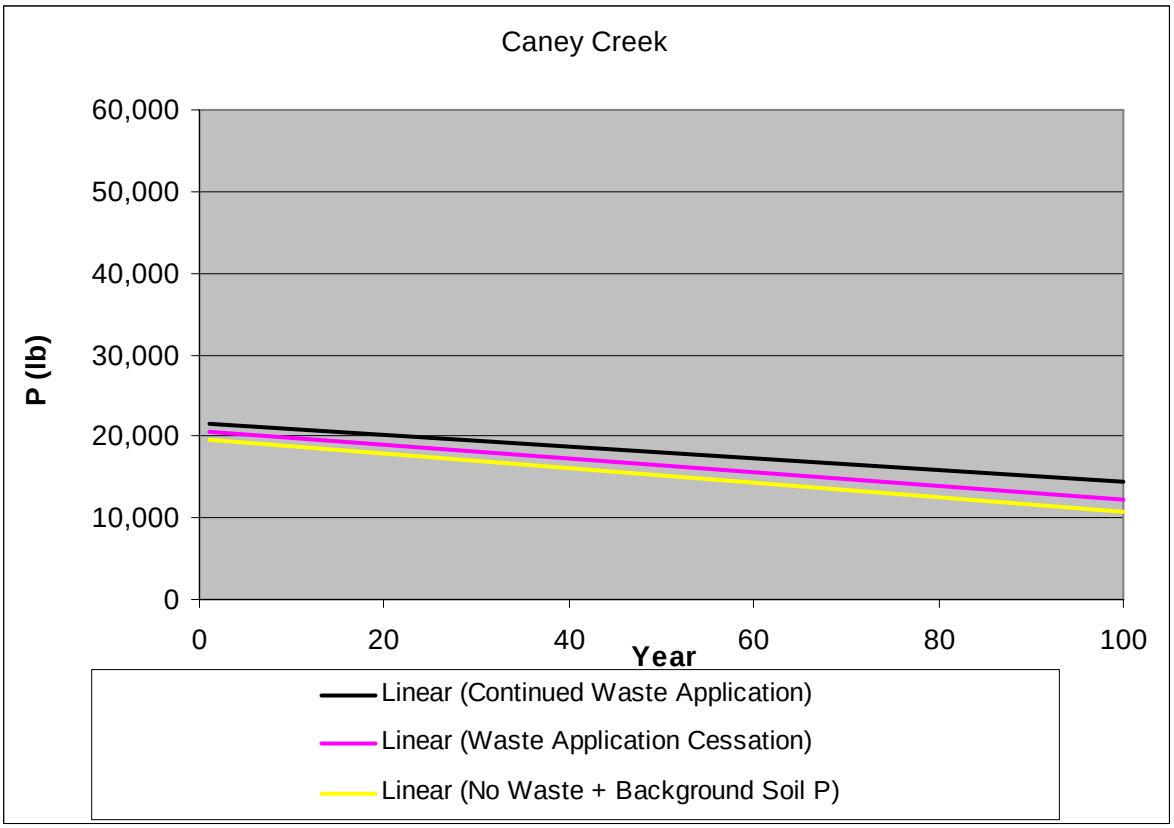

Figure 10.30. P Load Trend at Caney Creek for Background Soil P Levels with No Poultry Waste Application in the IRW.

Table 10.10. P Loads to IRW Waters with No Poultry Waste Application and Total P Load to Lake Tenkiller for Poultry Waste Application Cessation. Weather Repeats Every 10 Years So Results Are Summarized in 10 Year Periods.

	P Load (lbs)				
Years	Tahlequah	Baron	Caney	No Application Total	Total (Cessation)
1-10	1,459,510	564,346	183,250	2,207,106	4,535,255
11-20	1,582,399	395,882	190,544	2,168,825	3,707,475
21-30	1,427,610	353,571	175,957	1,957,138	3,164,230
31-40	1,324,859	298,238	162,037	1,785,134	2,784,794
41-50	1,239,752	262,416	148,617	1,650,785	2,512,765
51-60	1,162,163	244,948	136,771	1,543,883	2,323,273
61-70	1,116,031	236,478	132,303	1,484,812	2,213,865
71-80	1,080,154	224,058	130,725	1,434,937	2,113,394
81-90	1,059,954	206,617	128,024	1,394,595	2,032,222
91-100	1,045,454	191,125	127,271	1,363,850	1,961,163

10.6 Historical P Loads in Illinois River Watershed Streams and Rivers

P loads to Lake Tenkiller since 1954 have increased at approximately 8,000 lbs per year. Poultry waste application in the IRW is responsible for approximately 4,700 lbs of this increase each year.

Figures 10.31-10.33 show the modeled P loads from the IRW from 1950-1999. The trend line at the Tahlequah indicates P loads increase approximately 6,820 lbs/year and at Baron Fork by approximately 1,150 lbs/year.

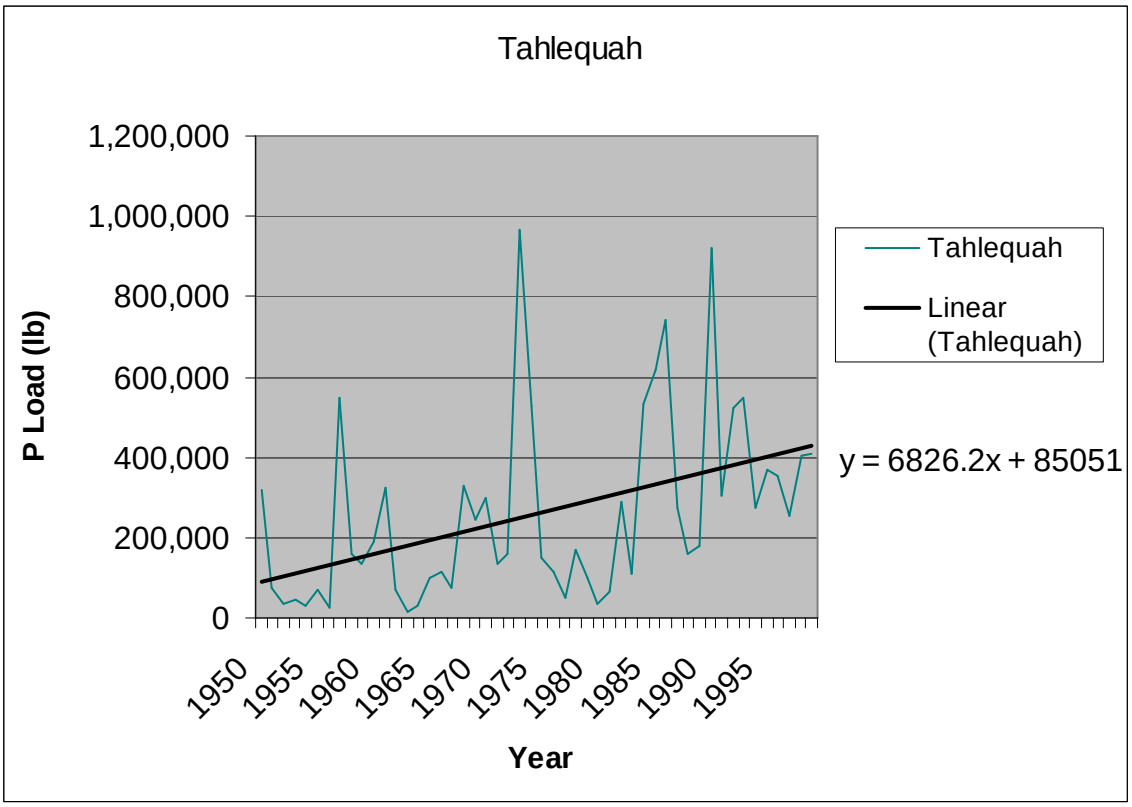

Figure 10.31. Modeled P Load and P Load Trend Line to Tahlequah from 1950 to 1999 Using Observed WWTP P Discharges and IRW Poultry Production

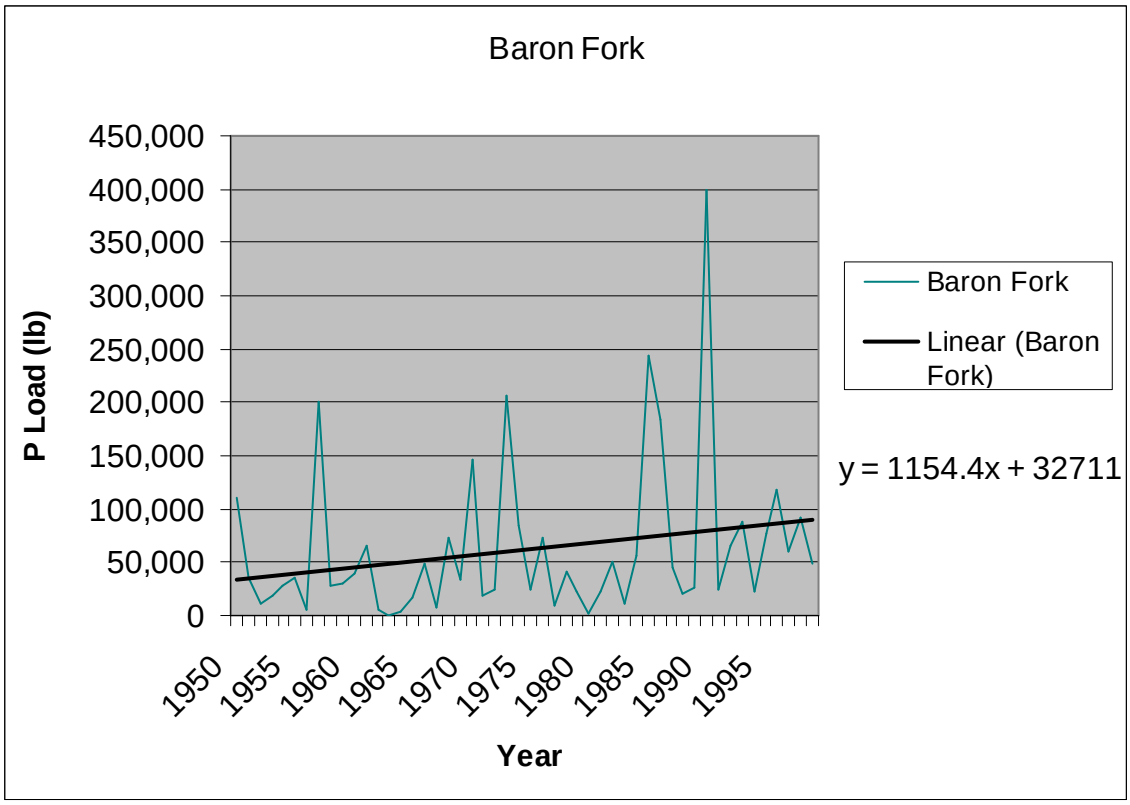

Figure 10.32. Modeled P Load and P Load Trend Line to Baron Fork near Eldon from 1950 to 1999 Using Observed WWTP P Discharges and IRW Poultry Production

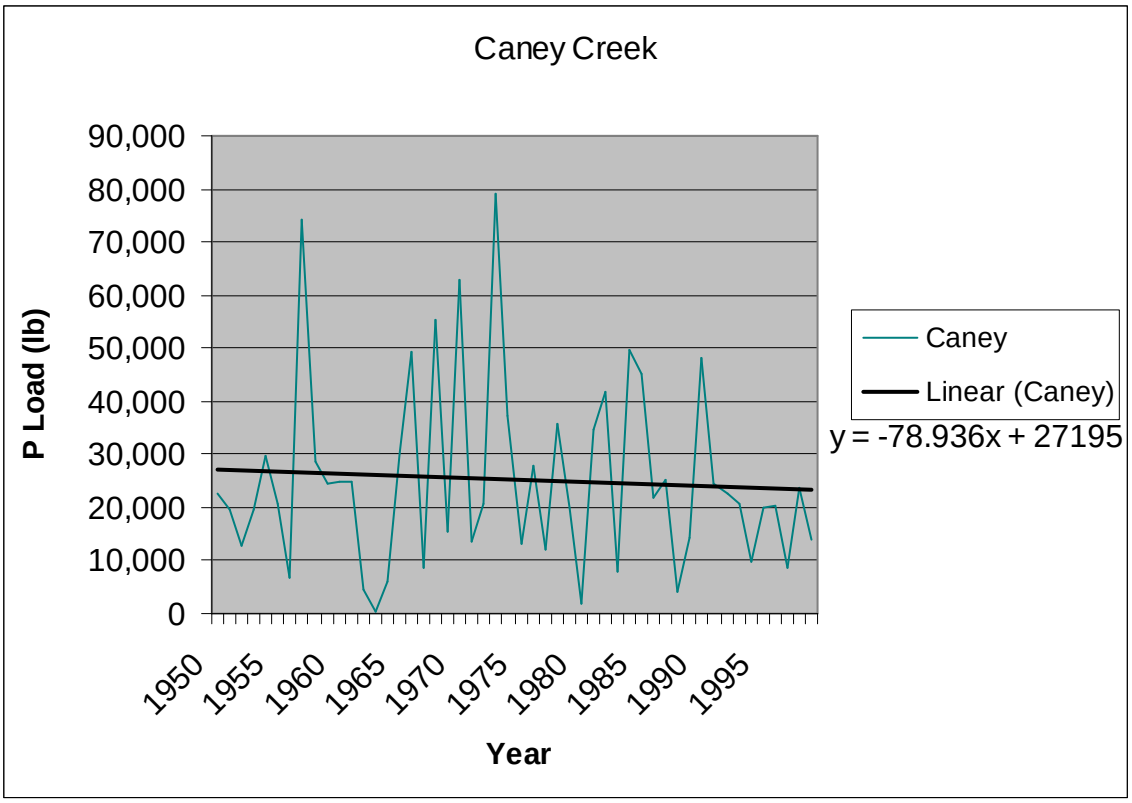

Figure 10.33. Modeled P Load and P Load Trend Line to Caney Creek from 1950 to 1999 Using Observed WWTP P Discharges and IRW Poultry Production

The NPS P loads from 1950 through 1999 are shown in Figures 10.34-10.36 for Tahlequah, Baron Fork at Eldon and Caney Creek. The WWTP P loads were not included in the results shown in Figures 10.34-10.36. The trend lines indicate P loads increase approximately 4,700 lbs annually due to NPS sources.

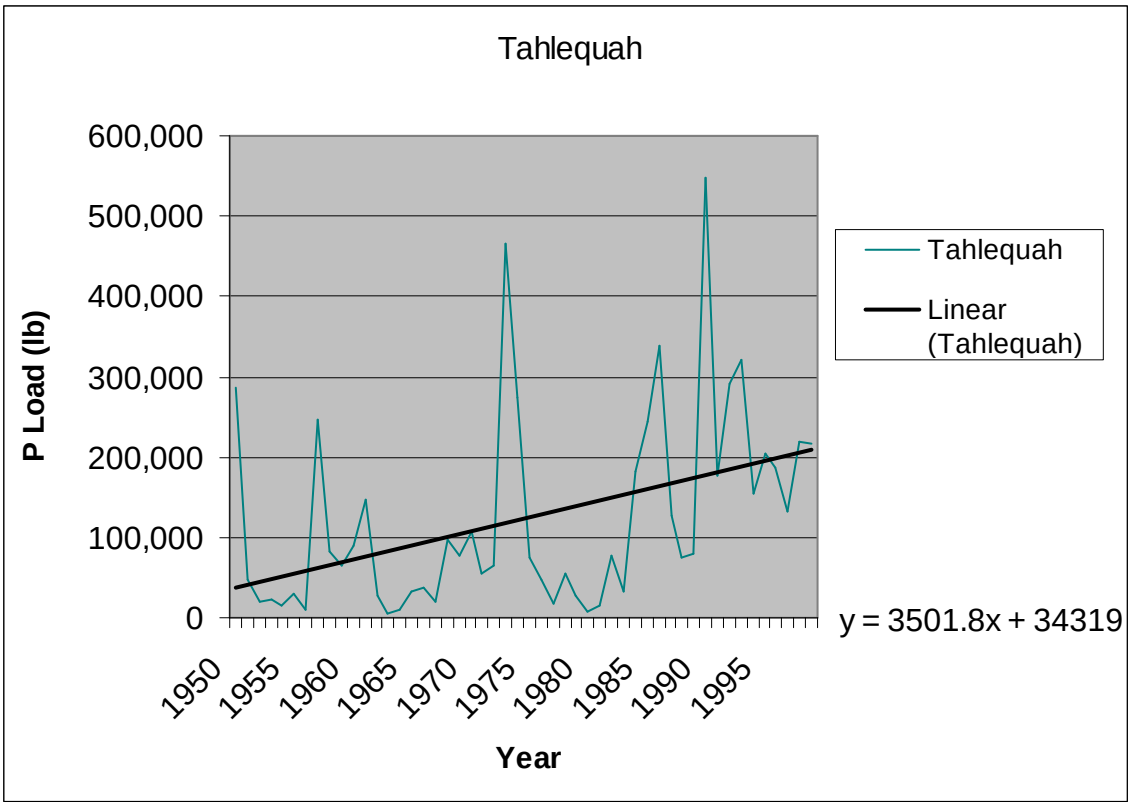

Figure 10.34. Modeled NPS P Load and NPS P Load Trend Line at Tahlequah from 1950 to 1999 Using IRW Poultry Production Data

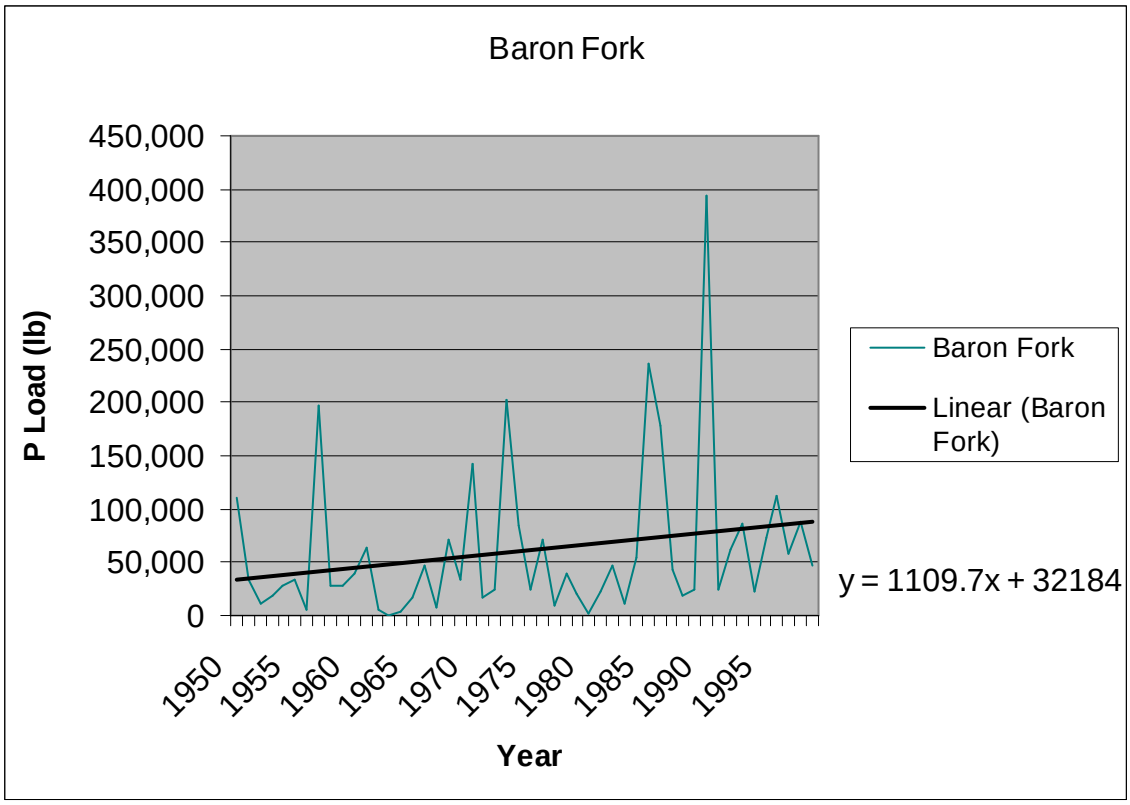

Figure 10.35. Modeled NPS P Load and NPS P Load Trend Line to Baron Fork Near Eldon from 1950 to 1999 Using IRW Poultry Production Data

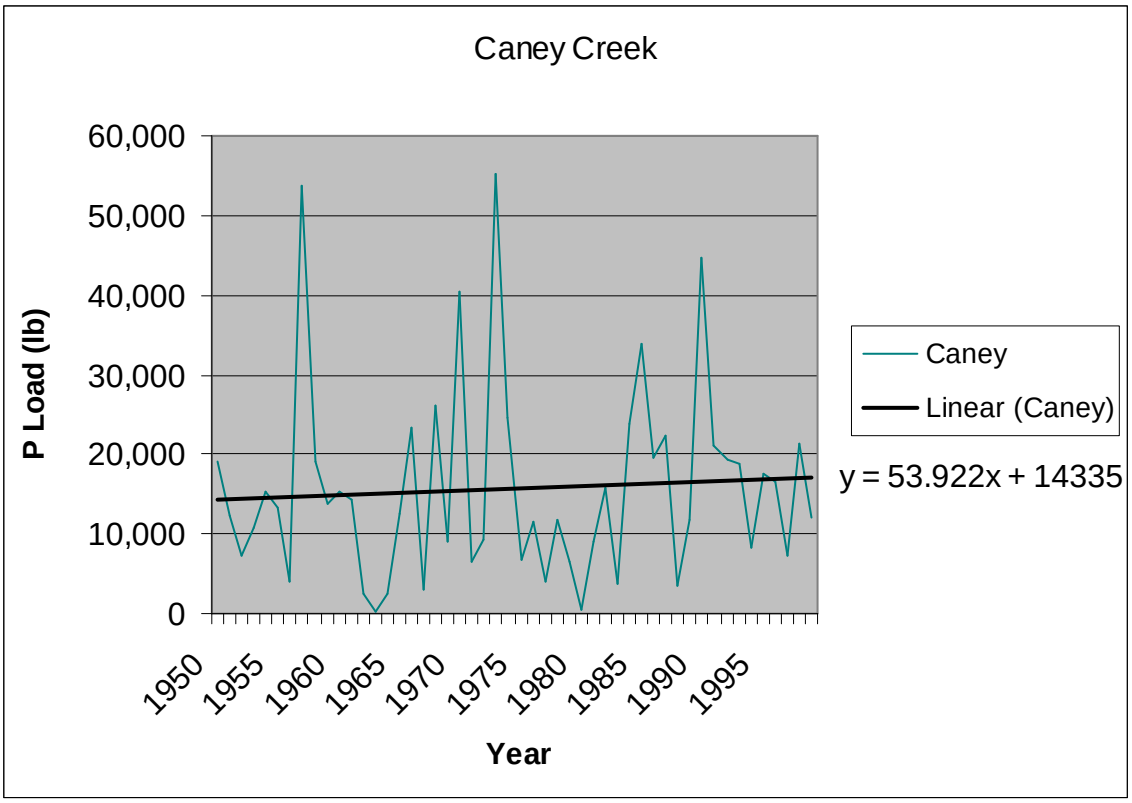

Figure 10.36. Modeled NPS P Load and NPS P Load Trend Line to Caney Creek from 1950 to 1999 Using IRW Poultry Production Data

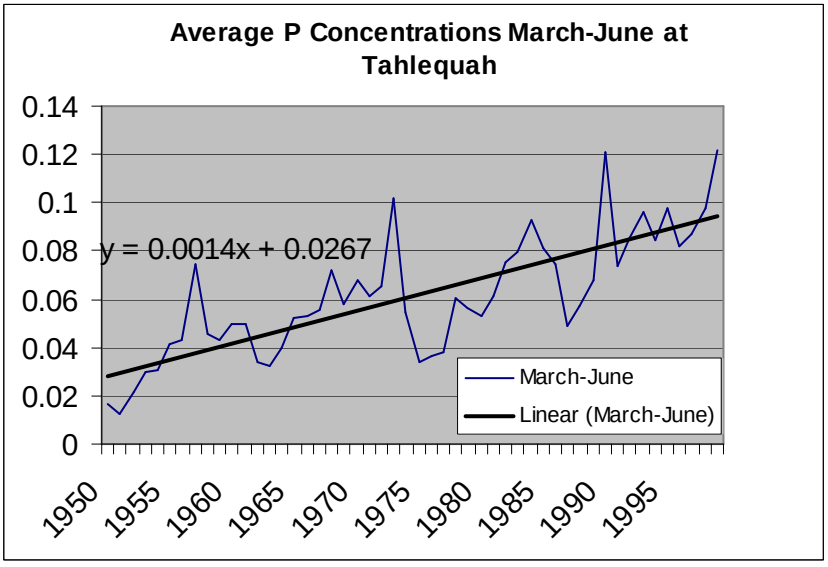

Figure 10.37. Average P Concentrations for March-June Annually at Tahlequah from 1950 Through 1999 Using IRW Poultry Production Data

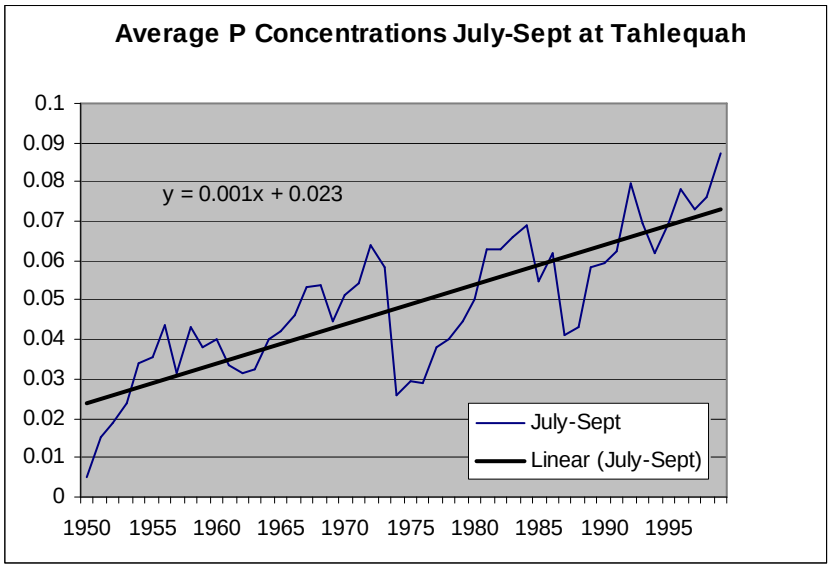

Figure 10.38. Average P Concentrations for July-September Annually at Tahlequah from 1950 Through 1999 Using IRW Poultry Production Data

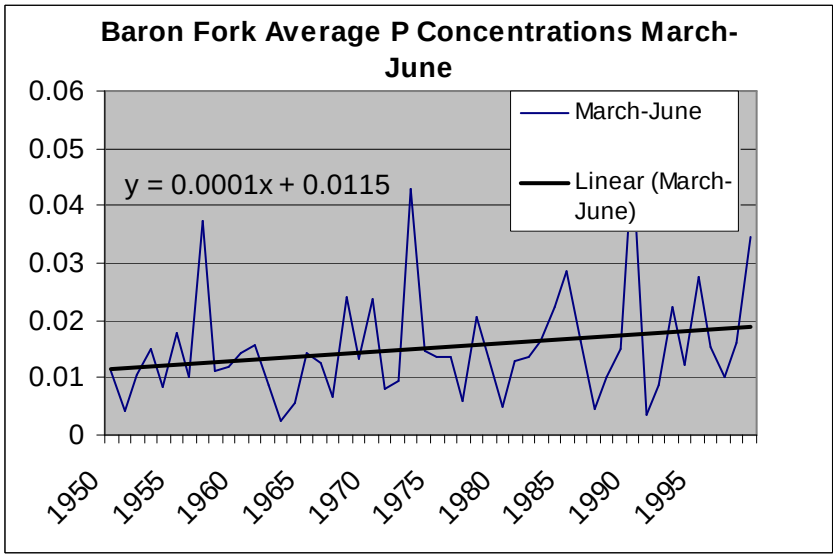

Figure 10.39. Average P Concentrations for March-June Annually at Baron Fork from 1950 Through 1999 Using IRW Poultry Production Data

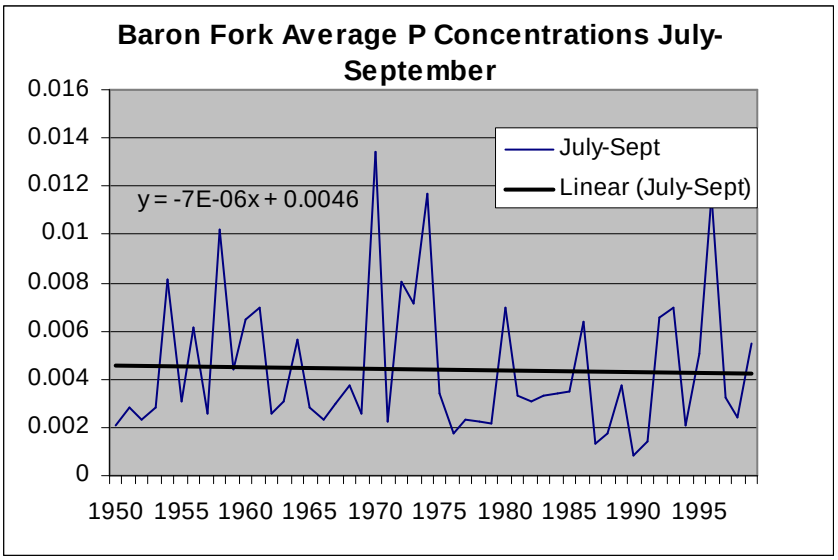

Figure 10.40. Average P Concentrations for July-September Annually at Baron Fork from 1950 Through 1999 Using IRW Poultry Production Data

Table 10.11. Statistical summary of phosphorus scenarios based on daily P output for Illinois River at Tahlequah

Treatment	N	Mean Daily P Load (lb)
Continue Waste Application	36525	528.1[a]
Waste Cessation	36525	260.8[b]
50 Year Growth	18300	690.6[c]
No Waste Background P	36525	155.3[d]
Waste Cessation + Buffer	36525	253.3[e]
Waste Cessation + Buffer All	36525	236.7[f]

Note: Means with the same letter are not significantly different at the 5% level.
N is number of observations (daily P loads)

Table 10.12. Statistical summary of phosphorus scenarios based on daily P output for Baron Fork near Eldon

Treatment	N	Mean Daily P Load (lb)
Continue Waste Application	36525	165.2[a]
Waste Cessation	36525	56.5[b]
50 Year Growth	18300	240.7[c]
No Waste Background P	36525	37.0[d]
Waste Cessation + Buffer	36525	53.8[e]
Waste Cessation + Buffer All	36525	48.1[f]

Note: Means with the same letter are not significantly different at the 5% level.
N is number of observations (daily P loads)

Table 10.13. Statistical summary of phosphorus scenarios based on daily P output for Caney Creek

Treatment	N	Mean Daily P Load (lb)
Continue Waste Application	36525	22.5[a]
Waste Cessation	36525	20.4[b]
50 Year Growth	18300	25.1[c]
No Waste Background P	36525	18.9[d]
Waste Cessation + Buffer	36525	19.3[e]
Waste Cessation + Buffer All	36525	16.8[d]

Note: Means with the same letter are not significantly different at the 5% level.
N is number of observations (daily P loads)

Appendix D

Table 7. Coefficients for P load routing models

Location	a	b	c	Initial P Accumulation (kg)
Tahlequah	0.1	$3.47 * 10^{-7}$	$1.05 * 10^{-10}$	500,000
Baron Fork	0.1	$4.7 * 10^{-13}$	$1.75 * 10^{-9}$	70,000
Caney Creek	0.1	$9.2 * 10^{-12}$	$1.25 * 10^{-7}$	5,000

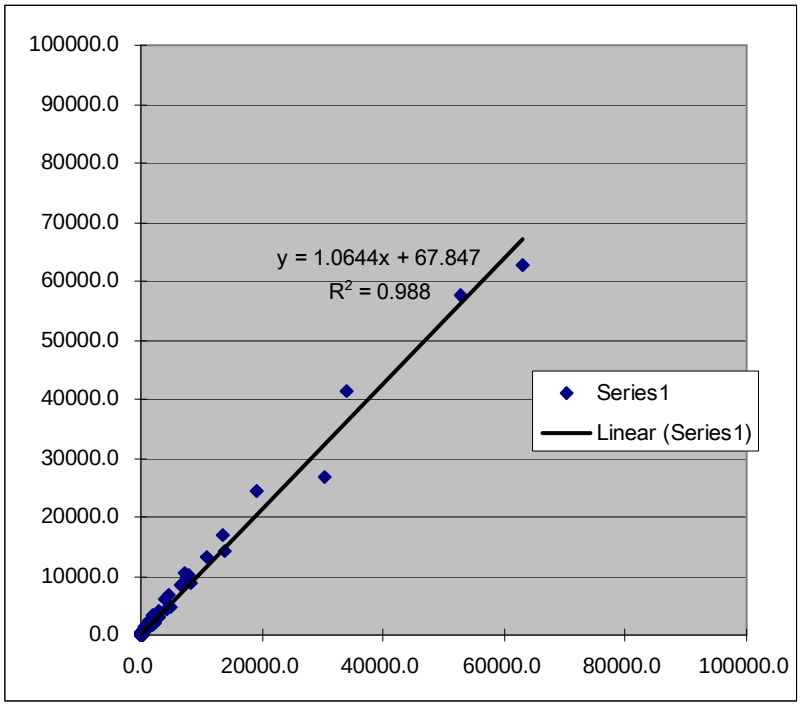

Figure 15. Calibration for Daily P Load at Tahlequah

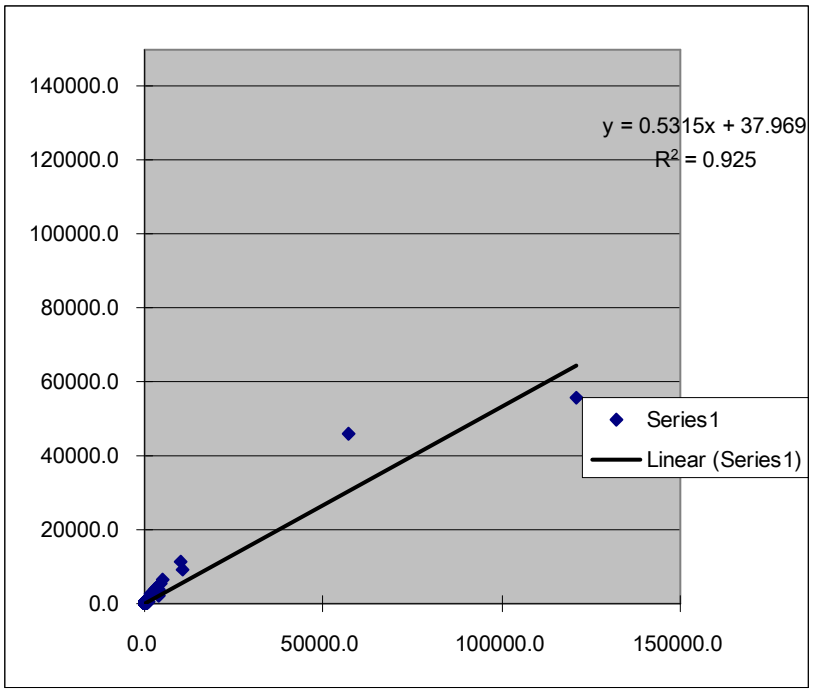

Figure 16. Calibration Results for Daily P Load at Baron Fork near Eldon

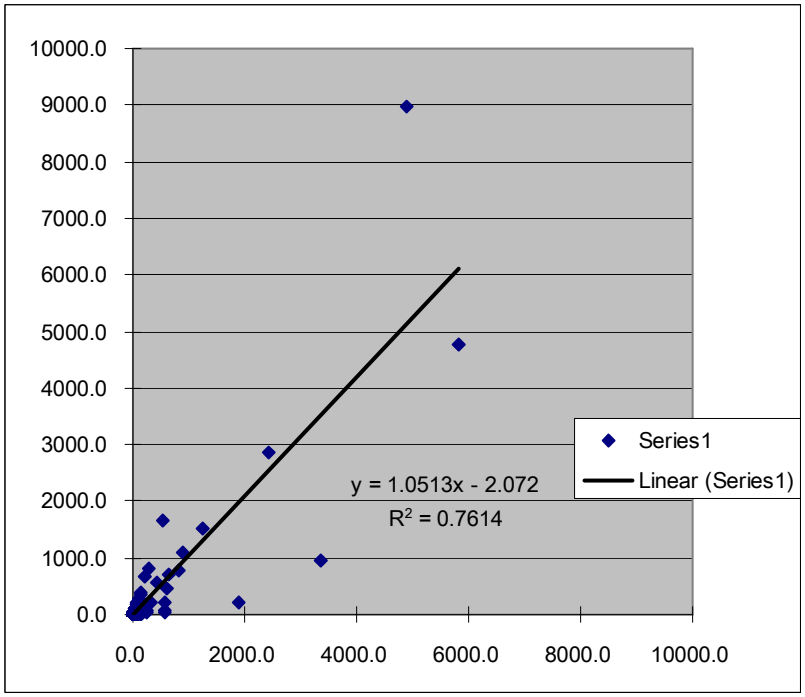

Figure 17. Calibration Results for Daily P Load at Caney Creek

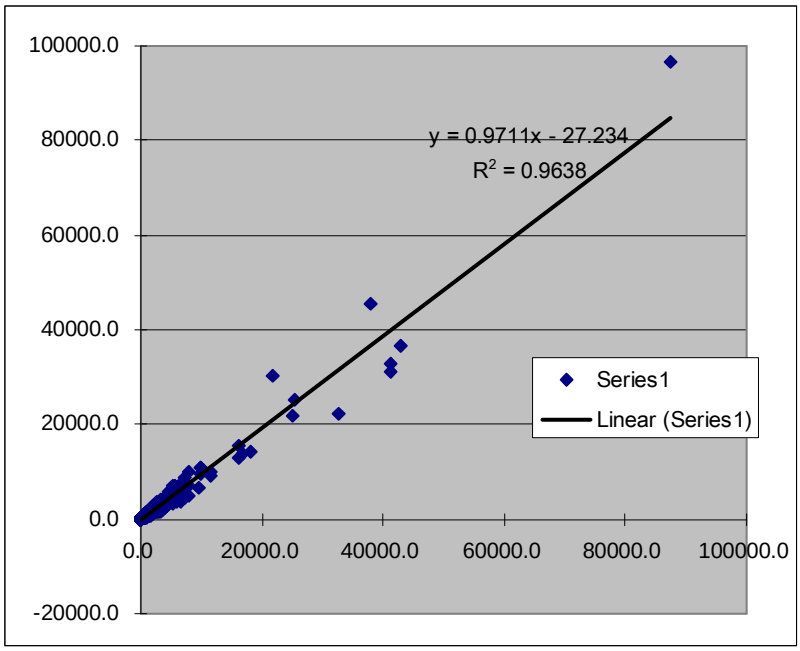

Figure 18. Validation Results for Daily P Load at Tahlequah

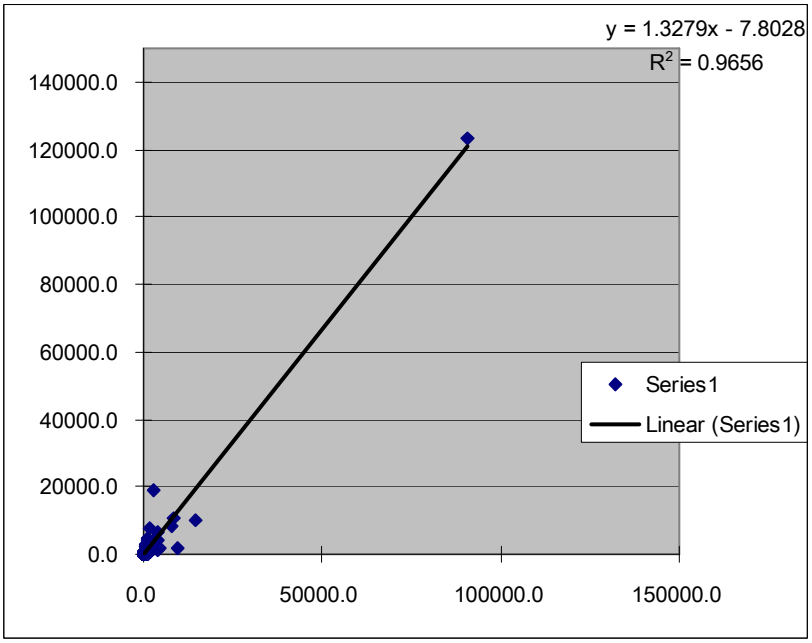

Figure 19. Validation Results for Daily P Load at Baron Fork near Eldon

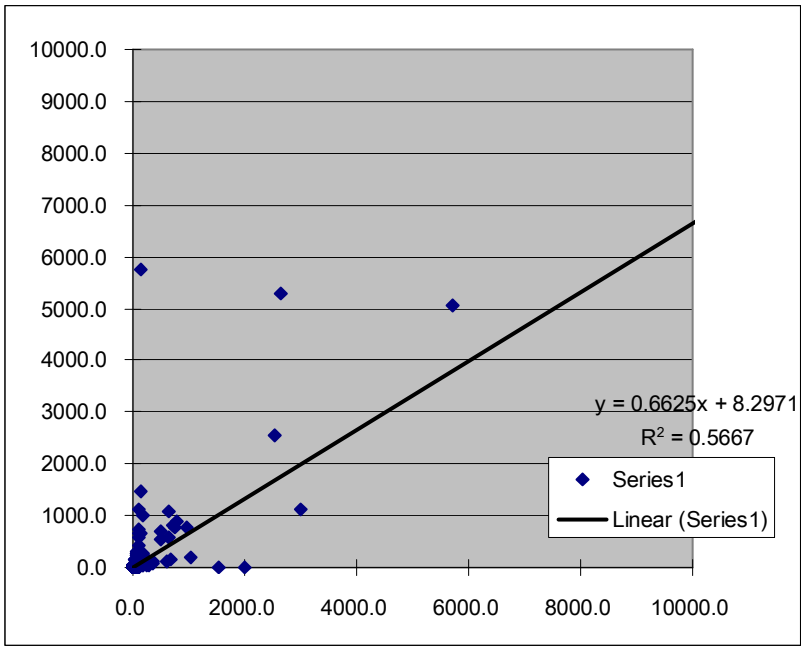

Figure 20. Validation Results for Daily P Load at Caney Creek

Table 12. Nash-Sutcliffe Coefficients (Daily) for P load calibration and validation

Location	**Calibration**	**Validation**
Tahlequah	0.96	0.98
Baron Fork	0.83	0.76
Caney Creek	0.55	0.65